the Petroleum Engineer

FOR MANAGEMENT

10th Annual Survey of World-Wide Petroleum Operations

Oklahoma's Deepest Production

They Moved a River

Refining in the Delaware Valley, USA

INTEGRATED EDITION OF THE PETROLEUM ENGINEER

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Each year, hundreds of thousands of bit records and dulled bits are analyzed by Hughes engineers in evaluating design and metallurgical changes. This is another *big* reason why the performance of HUGHES rock bits is the *world standard of the industry!*

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Dowell-developed rubber tanks provide large-volume storage for big frac jobs.

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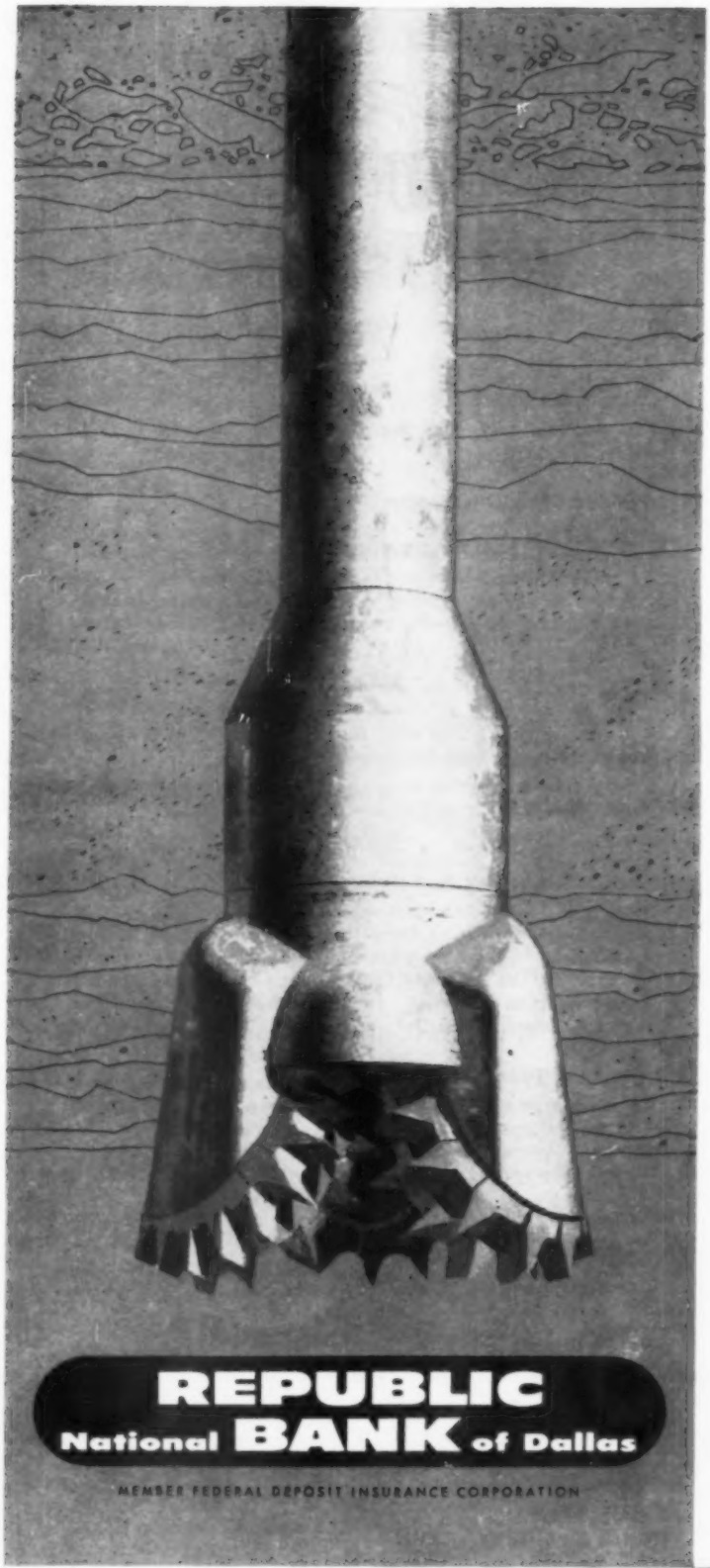

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A Magazine of Petroleum Management

the Petroleum Engineer

FOR MANAGEMENT

NUMBER 4 • VOLUME XXIX • APRIL, 1957

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THEY CAN'T LOSE FOR WINNING

There are still a few nations who haven't caught on to the surest gamble in the world today. That is the trick of passing a fairly clear and half-way reasonable petroleum law that permits foreign companies to search for and develop oil and gas reserves.

It's a cinch! In the first place it doesn't cost a peso or a franc or a shilling or a yen. You don't even need a consultant because you can get model laws from nations who have already hired consultants. As one government official said, "Our laws are so drawn that they balance almost perfectly the attraction for companies on one side with the greatest possible returns to our nation on the other."

From all reports he knows what he's talking about. So far oil companies have spent far more money in his country than they've got out of it. The economic boost has been better than United States economic aid. You get technical know-how and money, too, and you don't have to knuckle under to State Department idea men.

Venezuela is the big showplace of what private enterprise can do away from home. David Rockefeller once said in an API speech that over a 15-year period foreign oil companies in Venezuela received a gross income of $4.5 billion. Of this, $1.7 billion went to the government, $1.125 billion went for wages and other operating expenses, $1.125 billion was reinvested directly in Venezuela, $0.5 billion was taken out of the country for stockholders. So 88 percent of the total contributed to the nation's economy.

Recently Venezuela opened up more land for oil concessions and 35 oil companies for the first time registered to do business in that country. Venezuela is going to get full benefit of its resources. In this country there is oil and plenty of it. What of those countries still in the possibility stage?

Guatemala is a good example of that. No oil showing yet but 30 some companies and individuals have concessions and are spending millions of dollars in the Central American nation. Instead of it costing the Guatemalan government to find oil and gas resources, the national treasury benefited before the companies even started to look. The companies paid for concessions and part of the money is already in highways that gave employment and now attract more tourists. The influx of oil company staffs and their families has added economic vigor in building, in services, and in retail sales.

Just the opposite are the nations that try to run their own oil operations. The state monopolies never seem to get the capital they need from the governing bodies. Perhaps because it usually takes so long and costs so much. Politicians just aren't that patient and neither are their constituents.

Guatemala, however, is ahead if oil or gas is never found. It can't lose – although the petroleum companies may.

Italy goofed. Last year it set up a complicated, inoperative law that hamstrings private companies. Gulf Oil, which found the best field ever discovered in this ancient land, was forced to get out. Italy's parliament followed the Communist theory to "let the stuff stay in the ground" rather than have foreigners profit.

Generally, that is just what the oil does – it stays in the ground – and nobody profits. The unfriendly nation takes the greatest loss, though, because petroleum companies can go elsewhere.

For this is true: A nation with sane petroleum laws gains whether or not there is oil or gas worth developing. It gains in material aid – money and technology – and it gains in friendship and learning.

The nation can't lose.

Ernestine Adams.

*Congrats and $25.00 to
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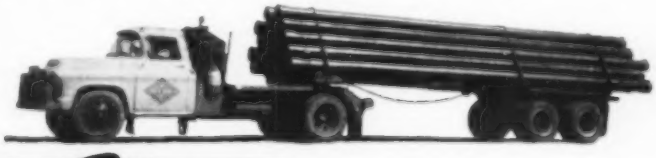
Neighbor, wherever you are, specify Lone Star and we both get a good deal.



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One HI-BRIN Pump always leads to more!

REPORTS from our sales organization show a startling similarity. This is a typical report: "Persuaded customer to install a HI-BRIN pump. Previous pump gave 3 to 5 months service. During latest visit (one year later) found original HI-BRIN pump still in service and customer had installed 3 more HI-BRIN pumps."

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Petroleum Profile

THE oil industry knows that heading up an integrated oil company is one of the most difficult of jobs, demanding outstanding executive ability in production, manufacturing and marketing.

Individuals who qualify for such posts are rare but Milton S. Beringer, president of The British American Oil Company Ltd., not only takes his job in his stride but has the distinction of being the first man in the 50-year history of his company to serve as chairman and president at the same time.

His tenure of office in the two chief posts of B-A has coincided with the company's greatest period of expansion. Last year Mr. Beringer's more than 40 years in the industry, 23 of them with B-A, were climaxed when British American acquired the assets of Canadian Gulf Oil. In one of the biggest transactions of its kind in Canadian industrial history, Mr. Beringer found himself guiding the progress of a company that had, literally overnight (the merger became official on July 1, 1956) almost quadrupled net reserves of crude oil, condensate and natural gas liquids; become the largest producer of natural gas in Canada and the largest producer of sulfur and liquid petroleum gases; increased undeveloped acreage by more than 9 million net acres in some of the potentially richest oil-bearing areas of Canada.

Milton Beringer was born in Gonzales, Texas, in 1893 and attended Texas A&M College, where he received his BS degree in chemical engineering in 1916. It was at college that he received the nickname "Fritz" by which he is known throughout the oil industry in Canada and the United States.

Apart from service as a second lieutenant with the 133rd Field Artillery, U. S. Army, in France in World War I, he has been associated with the petroleum industry ever since graduation. He first joined the Sapulpa Refining Company which later became part of Continental Oil. His employment on refinery construction took him as far afield as Ploesti, the Roumanian oil fields that played a dominant role in world oil prior to World War II.

Returning to the U. S. in 1929, he joined the Alleghaney-Arrow Oil Company and later the Northwest Stellarene Company. He was manager of that company's plant at Coutts, Alberta, when B-A bought it in the spring of 1934, and among the other assets acquired were the services of Mr. Beringer, retained as plant superintendent.

MILTON S. BERINGER
President
and
Chairman of the Board
The British American Oil Company, Ltd.

During the next 10 years he built B-A's Turner Valley absorption plant; refineries at Calgary, Alberta, and Clarkson, Ontario, and carried out ambitious expansion projects at the Montreal East refinery; as well as serving for periods as manager of the Calgary and Toronto refineries.

In 1945 he became manager of all the company's refineries and shortly thereafter was appointed vice president in charge of manufacturing.

As vice president he planned and supervised the biggest manufacturing expansion program ever undertaken by B-A. Refinery construction included a completely new plant at Edmonton, Alberta, and the doubling of capacity of the refineries at Montreal East and Moose Jaw, Saskatchewan.

In 1951, he was appointed chairman of B-A's board of directors and again the scope of his activity widened. Every working day found him busy in his office on the executive floor of the company's head office building, broadening his already-extensive knowledge of the various departments. His fellow directors acknowledged the value of his services to B-A by appointing him president of British American in 1955.

The company in which he holds the two top positions has exploration and production operations in the U. S. and Canada, crude oil and product lines, tankers, five refineries in four provinces and retail outlets throughout Canada.

He is also president and director of The British-American Oil Producing Company, and The Toronto Pipe Line Company, Dallas, Texas, and his other directorships include B.A.-Shawinigan, Ltd., the Bank of Nova Scotia and the Chartered Trust Company.

The considerable responsibilities he assumes have had little outward effect on Mr. Beringer. Nearly six feet, he carries well the 190-pound weight he has maintained with little variation since college days. Those who were associated with him in his early refinery days are happy that "Fritz" still retains the easy informality and courtesy and, whenever his crowded schedule permits, he is a welcome and inveterate mixer at company social events.

Mr. and Mrs. Beringer (the former Mabelle Robertson, also of Gonzales) have fitted happily into the social life of Toronto. Their participation is limited only by Mr. Beringer's preoccupation with B-A affairs. Their son, Milton R., a civil engineering graduate of the University of Toronto, is carrying on the oil tradition established by his father through his work for Gulf Oil Company at Philadelphia.

Mr. Beringer acknowledges (without a sign of regret) that B-A requires him to curtail the time he would like to spend hunting and shooting. Occasional golf games he regards as being more beneficial to his physical fitness than to his handicap.

you can judge

the comparative values of furnace design as applied to operating requirements.

It's quite simple

there are 9 basic factors which must be evaluated to obtain the full comparison of values

1—Average radiant transfer rate. 2—Maximum deviation from average radiant transfer rate. 3—Average and maximum transfer rate in convection section. 4—Maximum tube wall temperature, radiant or convection. 5—Maximum efficiency with specified excess air. 6—Controlled thermal recirculation of flue gases to provide even heat distribution throughout full length of each tube and equalized heat distribution around each tube. 7—Overload and corresponding transfer load. 8—Design to provide: structural column supports - Ladders - Platforms - Tube Removal facilities, etc. 9—Degree of assembly; of the furnace structure and of the heating surface.

Whenever all these 9 specifications are applied to all the operating requirements, you can be sure PETROCHEM ISOFLOW FURNACES will be found most economically desirable.

No other furnace design can claim the recognition and acceptance achieved by PETROCHEM ISOFLOW FURNACES . . . starting with one installation in 1940, January '57 records more than 1650 ISOFLOW FURNACES in operation and under construction—a record that is incomparable just as all Petrochem Isoflow furnaces are more economically desirable by any comparison.

PETROCHEM-ISOFLOW FURNACES

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THE CONFERENCE TABLE

First get your facts; and then you can distort them at your leisure—MARK TWAIN

People Are Pretty Important

Charles C. Gibbons begins his article on page E-3 with a story about a helmsman who ran his ship aground in a harbor just to follow orders. This is one of the "employee attitudes" that he discusses in this enlightening study of man and how a manager can get the best results in dealing with people.

We live in an age of human relations. We have learned at long last that people must be persuaded to run smoothly as well as the equipment they use.

A brief study of man's attitude is found in "Is Freedom Necessary to Science." It has appeared odd to us, and no doubt to you, that some top scientists who object strenuously to any security measures, in this country, very often insist that Russia is making greater scientific progress than we are. First is the question: Is Russia giving its scientists more freedom than the United States?

Another question is: Is freedom essential to a healthy, scientific climate? Dr. Dyson, who has visited Russia, gives his opinion and we have reprinted from *Science*, an editorial that discusses the questions.

Scientists in industry often work in secrecy for a certain period; rarely, however, in basic research but in competitive applied research.

How much freedom do you think is necessary for the best progress of scientific discovery?

What One Geologist Costs

If you want to hire a geologist you pay for his training one way or another. A new one you pay to learn, and an experienced one you pay for what he has learned. Even the new one has already paid some $18,000 for his bachelor's degree. It will cost you from $6,000 to $8,000 to give him the experience he needs.

A Johns Hopkins University professor, Dr. Ernst Cloos, compiled these results from a survey. He said cost of educating a PhD is even greater, ranging from $40,000 to $43,000. Dr. Cloos' theory is that this cost should be paid by those who want geologists—that is industry, government, and universities—together with those who have received an education. That seems to be about what is being done.

The student bears a cost of some $8000, which he pays or he is awarded a scholarship, which takes care of it. Sometimes this is given by industry and sometimes by a university. The cost to the university is about $10,000. If it's a state university, of course government (taxes) bears the cost. If it is a private university the cost is borne by industry and private donors. Those who have received an education support the government and industry whether or not they directly support the education of another geologist.

We're Getting Economics Conscious

In many ways, economics is a strange subject. It tries to collect the reactions of business and industry and trade and weave them into theories that can be applied to future operations. Only the simplest terms are accepted. As soon as economists reach a certain level of understanding, the experts branch off into a hundred different schools of thought.

And for the sake of future development, the people of the world must have a better understanding of economics, must learn "what works," "why it works" and how it effects people. In "Economic Growth and Instability" (W. W. Norton & Company, Inc., New York. Price $5), the author endeavors to give background and analysis to the dynamics of economics. Our principal reason for commenting on the volume here, is that this appears to be a book on economics that will appeal to engineers.

The first paragraph gives you a good clue to the discussion: "The subject of economic growth, of growth in real income, is second in importance to no other topic in economics. It is clear that if the population is growing, real income must also grow. Its failure to do so means a reduction in living standards to the point where population ceases to grow. In many, if not all, instances, this would mean mere physical subsistence. At the very least, then, if some given standard of living is to be maintained, income must grow in proportion to population. If living standards are to rise over time, the growth in real income must exceed that of population."

UN to Consider Offshore Oil

A report on the control of high seas and extent of territorial waters and covering the subject of access to oil under the sea, has been made by the International Law Commission. Now the legal committee of the general assembly of the United Nations is studying means of using the commissions' report.

You're a Readin' Man

It's hard to believe, but the average business man spends four hours a day in the office and one hour a day at home reading business reports, correspondence, books, newsletters, and business magazines. In his leisure time, about 10 hours a week are devoted to newspapers, magazines, and books.

This indication that the American business executive is among the most serious and persistent readers in the nation comes from an American Management Association survey.

It means that about one-fourth of all your waking hours are spent reading. If you are average, you prefer non-fiction to fiction, you read books on history, biography, science, and business management. Your favorite type of fiction is historical novels. You say that some of your reading time is wasted, usually because of "wordy or repetitious material" or "poorly organized or unclear material."

You spend a sixth of your total reading time on business magazines. In addition to the business magazines circulated by your company, you have personal subscriptions to an average of eight business and industry periodicals.

Invest in America

This year 50 cities will take part in the national Invest-in-America Week. The theme of the program is "Every American an investor in job, savings, homes, insurance, and securities." It is backed by banking, finance, and industry.

T. S. Peterson, president of Standard Oil Company of California, was elected national chairman. In accepting his post Mr. Peterson pointed out that this movement is the American answer to the Communist system that controls by fiat. Because of Invest-in-America, he said, millions of Americans today have a clearer understanding of the share each one owns in America through the free enterprise system.

Drive for White-Collarites

The AFL-CIO, through its Industrial Unions Department, launched a drive to organize 18 million white-collar workers, at a recent two-day conference in Washington. About 300 delegates from 21 unions were scheduled to attend. The department is headed by Walter Reuther who, according to press reports, gave some clues as to the arguments to be used in organizing those workers. Some of them follow:

1. Wages for factory jobs have now outstripped those for office and clerical.
2. Many office employees are given highsounding titles in lieu of proper salaries.
3. Women in offices are not being paid equally with men doing the same work.
4. Favoritism is being shown in promotions.
5. The principle of seniority is not being properly adhered to.
6. White-collarites have to press their own grievances.

This determined drive by the unions may have received some inspiration from the fact that for the first time in history white-collar workers outnumber the so-called blue-collar employees by 25,400,000 to 24,900,000. It is expected that white-collar workers will continue to increase more rapidly than the blue-collar workers because of the increasing mechanism of industry. This will have a growing influence in national affairs, especially on the political and economic front.

Pipeline Storage

Storage and distribution seem to be the least understood branch of the oil industry. Even after the remarkable study by the National Petroleum Council in 1954 there has been little comprehension even within the industry. API President Frank M. Porter pointed out that as much as 72 or 73 percent of the industry's crude oil inventories are tied up constantly in distribution and storage. Approximately 183 million of the 251 million barrels of crude oil reported in storage are purely functional. That is, this much oil is needed to fill pipelines, to fill tanks at refineries, to fill tankers that ply the ocean, to fill barges and tank cars.

"More than two-thirds of all the crude inventories reported by the Bureau of Mines as in storage, are actually unavailable and must remain unavailable if these transportation and refining facilities are to function properly," said Mr. Porter.

Everybody Goes to School

In an American Management series of classes recently, one lecturer gave these reasons for the sudden and blooming growth of management development courses:

1. General business growth and its diversity since World War II.
2. Complexity of business. The necessity for specialization.
3. Yesterday's neglect. There are very thin lines leading to top management.
4. Pirating by fast growing organizations. It became cheaper to buy executives than to build them.

AMA classes illustrate what has happened in the business world. This year, the AMA will conduct 700 courses in 16 cities of the United States. All of these are for top and middle management and cover virtually every phase of business and industry.

On Page E-9 is a second of our series on management courses at universities. This particular course at Texas A & M College has more teachers than students; which is rather an odd proportion.

Future issues of THE PETROLEUM ENGINEER will cover other courses created to give people more knowledge of their capabilities.

ASME Angle on Engineer Shortage

ASME recently reported on a survey of 880 men with engineering degrees. In response to the question, "What measures do you think should be taken to end the shortage of engineering manpower?" 65 percent of the answers suggested changes in current industrial practices.

.....31 percent said engineers should be provided with more technical assistance and clerical help, thereby freeing professional men for more creative work.

.....21 percent said to increase salaries to make the profession more attractive.

.....12½ percent wanted more recognition and prestige accorded engineers for their contributions to the economy.

Dr. William S. Ryan, president of ASME, said perhaps the most fundamental item was the well-founded feeling that engineers and their contributions to our economy are not sufficiently appreciated. We live in the age of technology—the Age of the Engineer—but very few people know of the achievements of this group.

Do You Write Your Senator?

Senator O'Mahoney, who is chairman of the joint anti-trust and interior sub-committee probing petroleum prices and the conduct of the emergency European oil lift, says he has received more than 500 letters—most of them supporting his "get-tough-with-the-oil-industry" attitude.

There are also several reports that congressmen and senators are getting floods of letters complaining of the high budget this year, and they seem to be paying some attention to their constituents' complaints.

There is no more effective way of keeping your viewpoint before the House and the Senate than to write a letter. You have as much right as anybody to get in your three or six cents worth, so why not do it? It may be the one letter that is needed for one vote. These days the men in the smoke-filled rooms do not have as much influence as that stack of letters, letters, letters.

Ten Biggest Oil Companies

From the giant Appraisal Survey compiled by John S. Herold, Inc. is this list of the 10 largest petroleum companies and their appraisal values in order of their size:

Standard Oil Company (New Jersey)	$10,821 million
Royal Dutch/Shell Group	6,320 million
Texas Company	4,577 million
Gulf Oil Corporation	4,329 million
Socony Mobil Oil Company	4,175 million
Standard Oil Company (California)	3,591 million
Creole Petroleum Corporation	3,580 million
Humble Oil & Refining Company	3,479 million
Standard Oil Company (Indiana)	3,426 million
British Petroleum Company	2,865 million
	$47,163 million

The Appraisal Survey of the 105 oil and gas companies is $45; published by John S. Herold, Inc., 250 Park Avenue, New York 17, N. Y.

HIGHLIGHTS

★ ★ ★

Digest of News and Comment

Record free-world tanker fleet is planned. National Petroleum Council has announced that construction of a record 38,000,000 deadweight tons of ocean-going petroleum tankers is scheduled for the next 10 years. This represents an increase of 9,066,120 tons in planned tanker construction since the NPC made public a preliminary report last December. This indicates a net 82 percent increase in the size of the free world tanker fleet between 1957 and 1965.

★ ★ ★

East Texas oil pioneers were memorialized March 22 at monument unveiling ceremonies near the C. M. (Dad) Joiner discovery well in Rusk County. Monument is a joint of pipe selected from the millionth ton of oil country tubular goods manufactured by Lone Star Steel Company, co-sponsor of the event with the East Texas Chamber of Commerce. Memorial site is in Pioneer Park, near the Joiner discovery on the Tyler-Henderson highway.

★ ★ ★

Not all Britons are resentful as to amount of oil sent during the Suez pinch—although this news seems never to make the front pages of our newspapers. British Ambassador to the United States Sir Harold Caccia recently told newsmen that "England is grateful for what Texas has been able to do, and anything more that can be done will be welcomed." John Faxon, Dallas Times Herald, mined this information from the Manchester Guardian.

★ ★ ★

Oil consumption restrictions in Europe must remain in force until oil and gasoline stocks are somewhere near normal, say officials of the 17-nation OEEC. Stocks must be built up for next year, and Europeans have been advised against "a false sense of security," because of the many still unknown political factors in the Middle East. The group has reported that some 95 percent of Europe's needs will be covered in April, May, and June.

★ ★ ★

Sticking to two grades of gasoline, rather than marketing three, Atlantic Refining Company has decided to upgrade its premium gasoline. The new gasoline will sell for four cents, rather than three, higher than regular gasoline Atlantic now markets. New fuel will be called "Atlantic Imperial."

Three natural gas industry segments and a Federal Power Commission representative will be brought together for a panel discussion highlighting the eleventh annual meeting of the Texas Independent Producers and Royalty Owners. Meetings are May 19-22, Galveston, Texas. Participants are J. J. Hedrick of Chicago, president of Natural Gas Pipeline Company of America and of Independent Natural Gas Association of America; J. E. Heyke, president, Brooklyn, (New York) Union Gas Company; Federal Power Commissioner William Connole of Washington, D. C., and Arch Rowan, Fort Worth, independent producer and TIPRO gas committee chairman.

★ ★ ★

California offshore drilling is being needlessly blocked for at least a year, according to Western Oil and Gas Association. State legislature's January action halted leasing under the Cunningham-Shell act, which was brought on—the association claims—by the "clouded" report of Assemblyman Miller. This report intimated that 12½ percent royalty, as called for in the Cunningham-Shell act, was not enough for the state's share even on rank wildcat location.

★ ★ ★

Independent oil operators in the Southwest are making a strong appeal for "immediate implementation" of recommendations of the Cabinet Fuels Policy Committee. Companies have been instructed to file import plans with the ODM to determine what action should be taken to curb foreign imports under the Trade Agreements Extension Act of 1955. A. E. Hermann, TIPRO president, insists that "Steps should be taken now . . . to make importing companies understand that the government means business."

★ ★ ★

Jet fuel demand in the U. S. has blasted from 3 million bbl in 1949 to 64 million in 1956, with nearly all of increase going to the military. U. S. production of 100 octane and up "av gas" rose from 35 million bbl in 1949 to 87 million last year. Reasons include increased air traffic and ferocious appetite of new planes. Example: One DC-7B commercial airliner consumes 2200 gal of 115/145 octane gas on a 1100 mile Miami-New York trip. A one-engine jet consumes 10,000 gal of fuel in one hour.

Largest helicopter fleet in the oil industry, owned by Humble Oil & Refining Company, is being made larger by the addition of two 12-passenger "whirleybirds." The new planes bring Humble's air fleet to 13, all servicing offshore operations in the Gulf of Mexico. It is reported that additional helicopters are to be added during the year.

★ ★ ★

More than 2000 inquiries and applications have been received by the recent announcement of the expanded Shell Merit Fellowship program for high school science and mathematics instructors. Cornell and Stanford universities are processing applications and will soon name 90 teachers who will attend the graduate-level seminars this summer.

★ ★ ★

Non-union production and maintenance employees of the Plymouth Oil Company, Sinton, Texas, have again rejected representation by the AFL-CIO Oil, Chemical and Atomic Workers Union. Taken by National Labor Relations Board, the ballot is one of several in recent years in the attempt to unionize Plymouth Oil workers.

★ ★ ★

Anti-trust immunity for participants in the Oil-for-Europe program has been termed vital by Stewart P. Coleman, chairman of the Middle East Emergency Committee. Without this immunity, Coleman told Congress, it would have been utterly impossible for the group to help manage the program. Under rules for the Committee, 15 participating major oil companies were allowed to review, free from anti-trust prosecution, each other's oil supply figures and related data to help map a complete picture of Europe's oil needs and available supplies.

★ ★ ★

Crude price increase amid the Suez crisis continued to be bombarded in Washington during March. Price-fixing, anti-trust implications, untimely, and unfair-advantage charges were suggested by several groups investigating the oil industry. Coming to the defense of the oil price hikes have been nearly all oil associations and organizations, as well as heads of individual companies justifying their price adjustments to meet rising production costs and create stimulus to obtain crude needed to fill lines.

SCRUBOSPHERE* ...

... FOR *Cleaner Gas* AT *Less Cost!*

***PEERLESS SPHERICAL DUST and LIQUID SCRUBBER FOR GAS PIPELINES**

(A) The majority of incoming liquid and solid particles are directed down into reservoir. 1

(B) Lighter solid particles carried by gas stream are separated on surfaces of contactor which are kept wet and clean by revolving thru liquid reservoir. 2

(C) Contactor is revolved by explosion-proof gear motor.

(D) Mist Extractor removes any remaining liquid particles from gas stream prior to outlet. 3

- The **dust removal ability** of the SCRUBOSPHERE **is superior** because it utilizes wetted surfaces for dust collection which are much more closely spaced than in conventional equipment.
- **Oil loss is minimized** because the oil used to wet the dust collecting surface is lifted mechanically instead of bubbling gas through the oil which results in foaming and loss due to creation of hard-to-separate fine particles.
- **Maximum performance and low cost** — The spherical design means high capacity and performance because it provides maximum dimensions for the contactor and mist extractor which normally are limiting factors in scrubber designs. The vessel cost is reduced because required vessel thickness is only one half that required for cylindrical vessel of same diameter.
- **Versatility** — separates solid and liquid particles with equal efficiency.
- **Low pressure drop** — ½ to ¾ psi at rated capacity depending on nozzle size.

PEERLESS MFG. CO. DALLAS TEXAS

PEERLESS MANUFACTURING CO.

P. O. BOX 13165 DALLAS, TEXAS

Representatives in All Principal Cities

Write for test data showing dust removal and oil loss of Peerless Scrubosphere as against conventional dust scrubber

Texas crude oil production has been cut back to 3,564,665 bbl daily through the month of April, based on a 16-day flow schedule. The decreased allowable marks the reversal of an upward trend that began last November to meet abnormal needs brought on by the Middle East situation. Even now, some crude purchasers are reporting that petroleum offerings were going untaken.

★ ★ ★

Stretching tanker capacity is being taken literally by virtue of a new "jumboizing" process being employed by a group of East Coast shipyards. First of the new vessels is slated for completion this month. It is the S. S. Amoco Delaware, owned by the American Oil Company. Six companies have contracted to enlarge and revitalize some 19 ships this summer. Ships of the Amoco Delaware class, already nearing the end of their life span, are enlarged in length from 523 to 571 ft, beam widened from 68 to 75 ft, cargo capacity increased from 140,000 to 175,000 bbl, and expectant life doubled. Only two months work is involved in the process.

★ ★ ★

Syrian legislature approved a law forcing Iraq Petroleum Company to pay back wages to some 3000 native employees out of a job for nearly four months — because of Syria's destruction of a portion of the company's pipeline moving across that country. Iraq Petroleum has advanced the Iraqi government $70,000,000 in oil royalties to make up loss of royalties lost during the Suez crisis.

★ ★ ★

Petroleum Liquid Quantity Measurement subcommittee of the American Petroleum Institute has been named by John G. Pew, chairman of the API president's advisory committee on standardization. Heading the new group are H. C. Packard, New York, chairman; A. H. Newberg, Service Pipeline Company, Tulsa, vice chairman, and E. O. Mattocks, director of the Institute's department of technical services, secretary. New subcommittee will be concerned with policy matters, including coordination of all existing and new undertakings in oil measurement.

★ ★ ★

Crude allowable cutback in Louisiana will be experienced this month. Conservation Commissioner John B. Hussey announced that his state is trimming some 60 to 70,000 bbl daily from the record flow set in March. The state's allowable was set at 920,000 bbl daily in April, to compensate for European deficits being made up from reopening Suez Canal and the Iranian pipeline.

★ ★ ★

Investigation of pipelines was begun April 1 by the Texas Railroad Commission, as a result of independent producers' charges that major crude buyers are holding back movement of Texas oil. Commission is searching out details surrounding (1) lack of pipeline connections on new wells in Texas, (2) conversion of crude lines to products lines made without prior consent of the Commission, and if these charges should be nullified, (3) discrimination by common carriers in buying and moving oil, and (4) whether crude output constitutes waste by being in excess of transportation or market facilities or reasonable market demand.

★ ★ ★

Oil is holding the line against inflation, B. Brewster Jennings, chairman of the board of Socony Mobil Oil Company, Inc., illustrated in a recent letter to employees. Socony Mobil products prices of mid-February were 7 percent higher than in June 1953, time of last crude increase . . . compared with Government's index for metals and metal products, up 20 percent; wage and benefit payments to employees, up 15 percent.

Oil-to-Europe program, scheduled to die on March 31, was extended to April 30, according to Interior Secretary Fred Seaton. At the end of March, oil flow through the Syrian-damaged pipeline was returned to 40 percent of normal. Movement of oil to the Syrian Mediterranean terminal at Banias marked an end to the 128-day flow stoppage.

★ ★ ★

Venezuelan government received in taxes some $334 million in 1956 from Creole Petroleum Corporation — a sum equaling the company's net income from its Venezuelan operations. This payment included production, income and other taxes applicable, in accordance with the 50-50 principle of Venezuelan income tax law, but does not include the $27,103,693 paid by Creole for new concessions acquired last year. Creole's Venezuelan production reached a daily average of 1,080,100 bbl, and crude refining reached an average of 274,883 bbl daily last year.

★ ★ ★

New Mexico crude production allowable is two barrels per day per basic unit less in April, as set by the state Oil Conservation Commission. This month's allowable was set at 41 bbl compared with the March rate of 43 bbl. Decrease was attributed to a drop in domestic and European demand. Overall daily allowable was set at 323,891 bbl, 3880 bbl a day less than in March.

Canadian Petroleum Association's Compilation of 1956
Estimated Proved Reserves of Liquid Hydrocarbons in Canada
(In 35 Imperial gallon barrels which are equivalent to 42 U. S. gallon barrels)
(thousands of barrels)

	Proved reserves as of Dec. 31, 1955 (1)	Changes in proved reserves due to extensions (new oil) and revisions during 1956 (2)	Proved reserves discovered in new fields and in new pools in old fields in 1956* (3)	Production during 1956 (4)	Proved reserves as of Dec. 31, 1956 columns 1, 2 and 3 less column 4 (5)
CRUDE OIL					
Northwest Territories	53,707	—	—	449	53,258
Alberta and British Columbia	2,169,985	244,213	19,721	142,141	2,391,778
Saskatchewan	236,872	113,711	28,394	20,284	358,693
Manitoba	45,211	2,577	56	5,839	42,005
Ontario and New Brunswick	3,759	465	20	608	3,636
TOTAL CRUDE OIL	2,509,534	460,966	48,191	169,321	2,849,370
NATURAL GAS LIQUIDS	247,085	20,505	15,000	2,656	279,934
TOTAL LIQUID HYDROCARBONS IN CANADA	2,756,619	481,471	63,191	171,977	3,129,304

*Only a limited area is assigned to each new discovery even though the committee may believe that eventually a much larger area will produce, because in this report the committee is concerned only with actually proved reserves. Hence figures in this column may be considered minimum figures.
All natural gas liquids located in Alberta and British Columbia.

Good Wells Make Good News

April, 1957

SANDFRAC®—a Dowell developed service—is one of the most widely used formation fracturing treatments. Most lease crude oils can be used in Sandfrac. If necessary, they can be modified on location with addition agents to control thickness, fluid loss and emulsions. If suitable lease crude is not available, special refined oils can be used. This versatility, plus Dowell's experienced personnel and dependable equipment, make Sandfrac a profitable treatment for many wells. Want proof? Just look at these cases.

- **Duval County, South Texas**—(Old Well)—Completed in Queen City Sandstone through perforations 5129-5133 feet in April 1956, and tested 104 BPD 43.7° gravity oil. By June, well had gone completely to water. It did not respond to acid or emulsion breaker treatments. Then it was fractured with Sandfrac, using 5000 gallons of 21° gravity crude from another zone, and 5000 pounds sand. After treatment, well produced at field allowable of 102 BOPD. At market price of $3.10 per barrel, $534.33 treatment *cost was recovered in less than two days.*

- **Kay County, Oklahoma**—(New Well)—Open hole completion in Mississippian Chat 4148-4180 feet. Well tested 5 BOPD before treatment. Sandfrac, using refined oil, was selected because of crude storage costs and relatively low acid solubility of chat in this area. 500 gallons of Mud Acid spearheaded 10,000 gallons oil and 20,000 pounds sand. Injection rate down 5½" casing averaged 25.2 barrels per minute. *Six months after treatment, production had leveled off at 40 BOPD.*

- **San Juan County, New Mexico**—(New Well)—Completed in Gallup formation of the Bisti Field. Before treatment, well tested 3.5 barrels oil per hour. Sandfrac, with 35,000 gallons lease crude and 26,000 pounds of sand, was used. Injection rate down casing was 50 BPM. *After treatment, well tested 62 BOPH.*

- **Lawrence County, Illinois**—(New Well)—Completed in tight Benoist Sandstone in open hole 1860-1873 feet, well tested only a show of oil before treatment. Mud Acid spearhead preceded Sandfrac, using 10,000 gallons of lease crude, 10,000 pounds of sand and 250 pounds of F.L.A.* (Fluid Loss Additive). Injection was down 5½" casing at 29 barrels per minute. Production after treatment was 110 BOPD, stabilizing at 65 BOPD. At market price of $2.90 per barrel, *cost of $1,700 treatment was recovered in approximately one week.*

Dowell Engineers can help you tailor Sandfrac to the requirements of your well, or they may suggest another Dowell treatment for better results. Either way, it pays to deal with Dowell. For more information or service, call any of the 165 Dowell offices in the United States and Canada; in Venezuela, contact United Oilwell Service, or write to Dowell Incorporated, Tulsa 1, Oklahoma.

*Trade Mark of Dowell Incorporated

Services for the oil industry DOWELL

A Service Subsidiary of The Dow Chemical Company

MUELLER®

high pressure connections

There is no need to shut down those high-pressure oil, gas, water or steam lines to make additional connections. Mueller high-pressure drilling machines and fittings permit high-pressure connections to be made in complete safety, without loss of fluid. Mueller fittings of many types may be welded to lines, pressure vessels or storage tanks, then put in service under pressure with the Mueller DH-2 Drilling Machine – no expensive shut-down or drainage is necessary.

Mueller high-pressure fittings are equipped with an internal valve or completion plug, that can be inserted or extracted with the H-17145 Completion Machine. Completion plug permits removal of drilling machine and gate valve after cut has been made. An external completion cap is then installed over the fitting to provide a double seal.

DH-2 Drilling Machine Drills ¼" through 2¼" – power or hand-operated – automatic or manual tool feed – 14" boring bar travel – working pressures to 1200 p.s.i. at 100°F. – working temperatures to 500°F. at 1000 p.s.i.

H-17145 Completion Machine Inserts and extracts completion plugs or valve stems in Mueller NO-BLO® fittings. Reconditions valve seats in tees and valves.

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Meetings

April 1-4—**AAPG,** national convention, Kiel Auditorium, St. Louis, Missouri.

April 2-4—**Corrosion Control Short Course,** sponsored by Central Oklahoma Section of NACE and University of Oklahoma, University of Oklahoma Extension Study Center, Norman, Oklahoma.

April 5-6—**The Society of Petroleum Engineers, AIME,** Pacific Southwest Mineral Industry conference, Reno, Nevada.

April 6-10—**Petroleum Equipment Suppliers Association,** 22nd annual meeting, El Mirador Hotel, Palm Springs, Calif.

April 7-10—**ASME,** Instrument & Regulators Conference, Northwestern University, Chicago, Illinois.

April 7-12—**American Chemical Society,** 131st national meeting, Miami, Florida.

April 8-9—**Industrial Accident Prevention Association,** annual conference, Royal York Hotel, Toronto, Canada.

April 8-10—**ASME,** spring meeting, Dinkler-Tutwiler Hotel, Birmingham, Alabama.

April 8-10—**The Society of Petroleum Engineers, AIME,** open hearth and blast furnace conference, William Penn Hotel, Pittsburgh, Pennsylvania.

April 8-12—**American Welding Society,** Sheraton and Bellevue Stratford hotels, Philadelphia, Pennsylvania.

April 9—**AIChE, Philadelphia-Wilmington section,** one-day meeting, University of Pennsylvania Museum, Pennsylvania.

April 10-12—**National Nuclear Instrumentation Conference,** Atlanta, Georgia.

April 10-12—**API Division of Production,** Mid-Continent district meeting, Mayo Hotel, Tulsa, Oklahoma.

April 11-12—**West Texas Oil Lifting Short Course,** Texas Technological College, Lubbock, Texas.

April 11-13—**The Society of Petroleum Engineers, AIME,** Pacific Northwest regional conference, Portland, Oregon.

April 15-18—**Petroleum Industry Electrical Association and Petroleum Electric Supply Association,** 29th annual conference and exhibits, Shamrock-Hilton Hotel, Houston, Texas.

April 16-18—**National Petroleum Association,** 54th semi-annual meeting, Cleveland Hotel, Cleveland, Ohio.

April 18-19—**Permian Basin Oil Recovery Conference,** sponsored by AIME and Texas Petroleum Research Committee, Scharbauer Hotel, Midland, Texas.

April 22-25—**Canadian Institute of Mining & Metallurgy,** annual general meeting, Chateau Laurier, Ottawa, Ontario, Canada.

April 24-26—**API Division of Production,** Rocky Mountain district meeting, Gladstone, Townsend, and Henning hotels, Casper Wyoming.

April 24-26—**Natural Gasoline Association of America,** 36th annual convention, Rice Hotel, Houston, Texas.

April 25-26—**API Board of Directors,** Dallas, Texas.

April 27-May 2—**Scientific Apparatus Makers Association,** Greenbrier Hotel, White Sulphur Springs, West Virginia.

April 28-30—**Independent Petroleum Association of America,** midyear meeting, Buena Vista Hotel, Biloxi, Mississippi.

April 29-May 1—**Southern Gas Association,** New Orleans, Louisiana.

April 29-May 1—**American Oil Chemists' Society,** annual meeting, Roosevelt Hotel, New Orleans, Louisiana.

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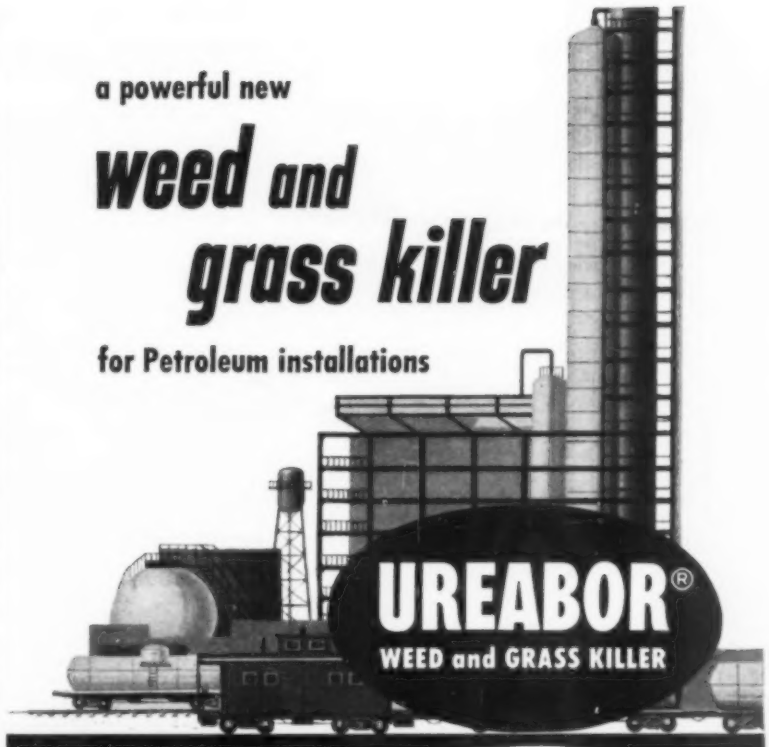

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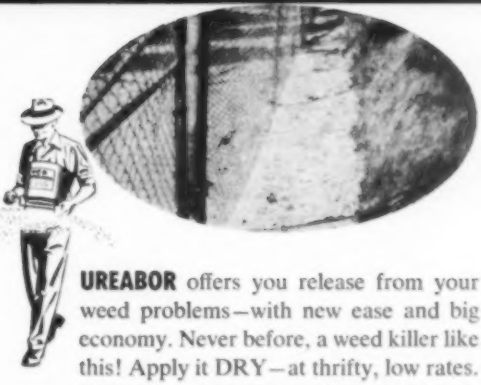

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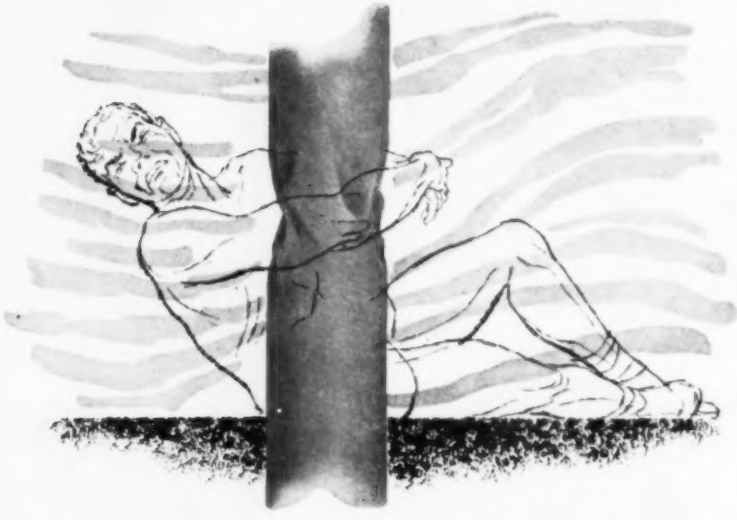

That's not poetic license, but sober, frightening fact! For the water itself, in many floods, is the very thing that is slowly choking the flood to death. Algae and bacteria (particularly the sulfate-reducing bacteria), not removed by treatment and ordinary filtration, travel into the flood zone with the flood water; there, in the heat and darkness, they thrive and multiply, reducing the permeability almost as effectively as cement. Down goes the drive, up go pump pressures!

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DICALITE DIVISION • GREAT LAKES CARBON CORP., 612 SO. FLOWER ST., LOS ANGELES 17, CALIF.

May 1-3—**API Division of Production**, Eastern district meeting, William Penn Hotel, Pittsburgh, Pennsylvania.

May 6-8—**API**, annual pipeline conference, Cleveland Hotel, Cleveland, Ohio.

May 6-8—**American Geophysical Union**, 38th annual meeting, National Academy of Sciences, Washington.

May 13-15—**12th Purdue Industrial Waste Conference**, Purdue Memorial Union Building, Purdue University, Lafayette, Indiana.

May 13-16—**API Division of Refining**, midyear meeting, Penn-Sheraton Hotel, Philadelphia, Pennsylvania.

May 16-17—**API Division of Production**, Pacific Coast district, Biltmore Hotel, Los Angeles, California.

May 19-22—**Texas Independent Producers and Royalty Owners Association**, 11th annual membership meeting, Galvez and Buccaneer hotels, Galveston, Texas.

May 19-23—**ASME**, Oil and Gas Power Conference, Kentucky Hotel, Louisville, Kentucky.

May 20-22—**NACE**, Northeast region spring conference, Syracuse University and Hotel Syracuse, Syracuse, New York.

May 20-24—**American Society for Testing Materials**, 5th conference on Mass Spectrometry, Commodore Hotel, New York City.

May 23-24—**The Society of Petroleum Engineers, AIME**, 3rd annual joint meeting, Rocky Mountain Petroleum sections, Northern Hotel, Billings, Montana.

May 27-29—**Rocky Mountain Oil & Gas Association**, Cosmopolitan Hotel, Denver, Colorado.

May 29-31—**12th Annual Short Course in Gas Technology**, Texas College of Arts and Industries, Kinasville, Texas.

June 2-6—**Air Pollution Control Association**, Golden Jubilee meeting, St. Louis, Missouri.

June 2-7—**SAE**, summer meeting, Chalfonte-Haddon Hall, Atlantic City, New Jersey.

June 3-5—**Petroleum Electric Power Association**, annual conference, Herring Hotel, Amarillo, Texas.

June 4-6—**Appalachian Underground Corrosion Short Course**, Morgantown, West Virginia.

June 6—**Pennsylvania Grade Crude Oil Association**, 34th annual meeting, Penn-Sheraton Hotel Pittsburgh, Pennsylvania.

June 9-12—**AIChE**, Olympic Hotel, Seattle, Washington.

June 9-13—**ASME**, semi-annual meeting, Sheraton-Palace, San Francisco, California.

June 9-14—**API Division of Production**, midyear committee conference, Muehlbach Hotel, Kansas City, Missouri.

June 10-12—**Interstate Oil Compact Commission**, midyear meeting, Canyon Hotel, Yellowstone National Park, Wyoming.

June 12-14—**Operations Research Conference**, sponsored by Illinois Institute of Technology, Illinois Institute of Technology campus, Chicago, Illinois.

June 19-21—**Association for Computing Machinery**, 12th annual meeting, campus of the University of Houston, Houston, Texas.

June 23-27—**Canadian Gas Association** meeting, Jasper Park Lodge, Jasper, Alberta, Canada.

June 24-28—**American Institute of Electrical Engineers**, 1957 summer general, Sheraton-Mt. Royal Hotel, Montreal, Quebec, Canada.

August 30-31—**Association of Desk & Derrick Clubs of North America**, annual meeting, Hilton Hotel, Chicago, Illinois.

Sept. 15-18—**AIChE**, Lord Baltimore Hotel, Baltimore, Maryland.

Sept. 22-25—**ASME**, Petroleum Mechanical Engineering conference, Mayo Hotel, Tulsa, Oklahoma.

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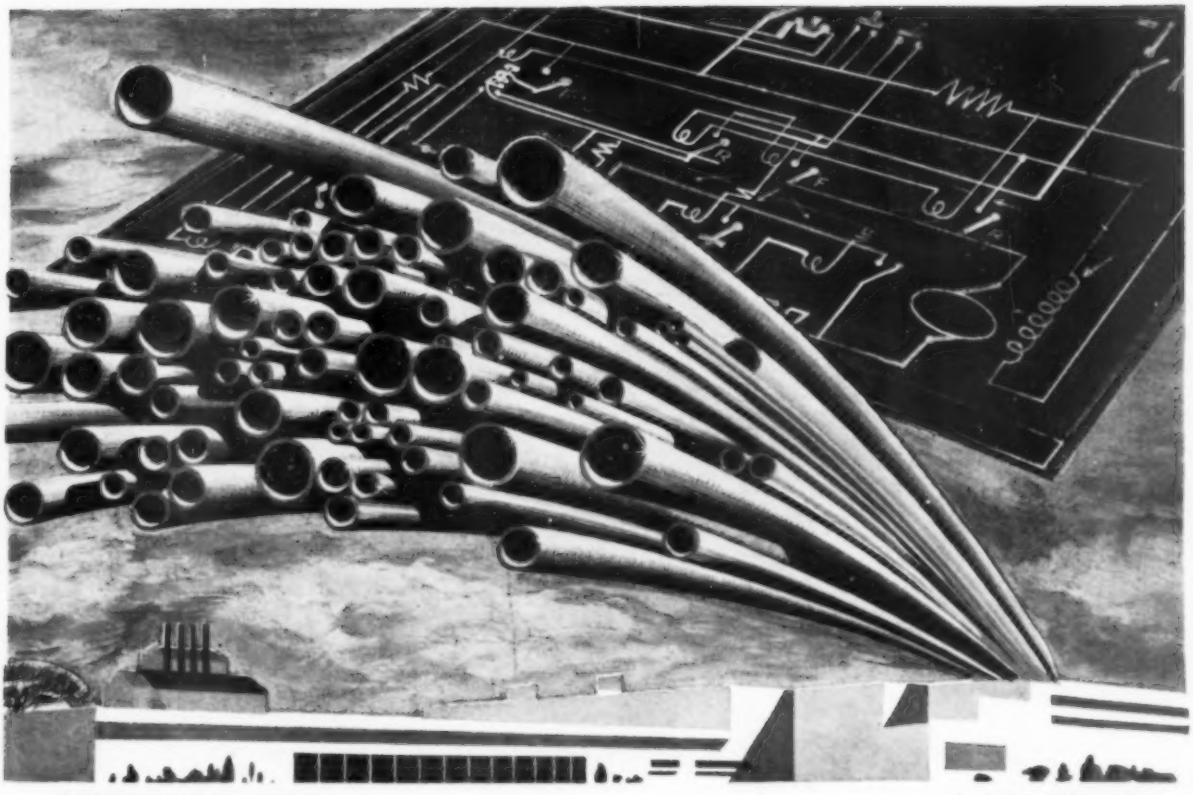

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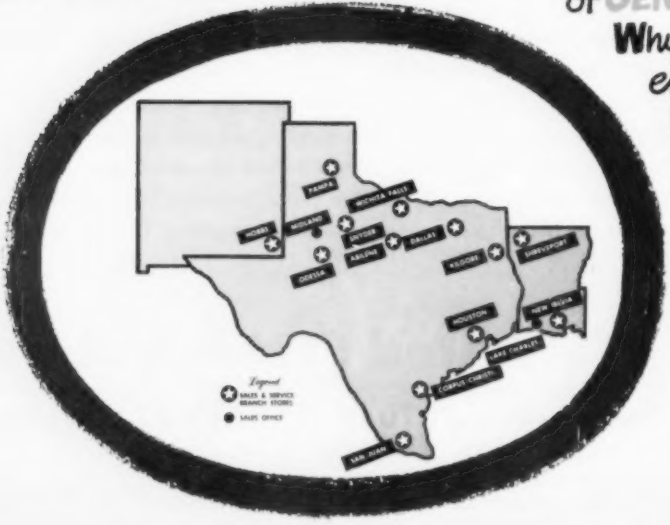

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Here is one of the new roads built in many corners of the world in order to haul a drilling rig to a selected site. The Texas Company constructed this road through rugged jungle country to a location in the Velasquez oil field, Colombia.

— Courtesy The Texas Company

Suez Fails to Slow Oil Progress

International petroleum proves its versatility once more when Middle East output is squeezed by politics. Instead of Mossadegh, this time Nasser called the turn that set up new shipping movements and pulled 100,000-ton tankers off the drawing board

Ernestine Adams

EIGHTEEN years ago, Shell and British Petroleum began searching for oil in Nigeria. The job was no well-guided safari. Jungles and heat fought back at every step the exploring parties took in the West African country. Then came the drilling rigs and their crews from across the sea and they struggled to closed-in drilling sites.

Eighteen years and $40 million later, oil was discovered. You can't put a price on the insect bites and the sweat, or the hard-won knowledge of where the oil might be. And you can't gage the difficulty of decision to spend millions on prospects of what the drill can bring you because nobody knows better than the men who decide, that oil is only where you find it.

This is just the first installment of the story. Now drilling crews are busy finding out if the oil at Oloibiri and at Afam comes in large enough volume to put in production equipment, pipelines and tanker loading facilities. Before Shell-BP Development Company of Nigeria can sell its oil, another $14 million is needed to get it to market.

Miss Adams is Management Editor.

Do you think this is an unusual adventure in oil? It isn't. It is repeated again and again. It is typical of the world-wide search for oil.

The first oil discovery came also to Costa Rica last year. Union Oil Company of California signed a contract in 1952 for a concession covering Limon and Guanacoste provinces in the Central American Republic. The new well was highly promising. It produced 1000 bbl a day of 46 gravity clean oil on test from 4950 ft. Situated about 1½ miles from the northeast coast of Panama, the well will have confirmation tests in Panama, where Union has another concession.

Nigeria and Costa Rica were only two of 109 nations, territories, and protectorates, where there was some kind of petroleum operation in 1956. In some, there were only exploration parties; in others, a refinery was processing crude oil shipped from production in another country.

Regrettably, the international oil industry was subject not only to the gamble of finding resources and to the economic laws of supply and demand. The industry again felt the iron whim of a political ruler.

Once again, a politico disrupted the international flow of oil and sent tank-

1956 REVIEW

This brief survey of petroleum activity during 1956 is the latest chapter in worldwide progress. Incomplete by itself, it is the continued story of oil and gas operations presented annually. This particular progress report gives highlights of events in 109 nations, territories, and protectorates.

Information comes from petroleum agencies of the countries and from companies handling the operations. We are deeply indebted for prompt and explicit data from these authoritative sources.

This material can be useful as a quick reference and combined with the nine former annual reviews, provides chronological background for any or all countries that have any operations connected with petroleum.

Reports on the Soviet and its satellites are filtered from scarce information that appears in their publications. Plans and achievements are sometimes difficult to separate and we present them for what they are — our best guess.

ers scurrying over the seas to find supplies and carry them to centers of demand. In 1951, Premier Mossadegh took over Iran's 700,000-bbl-a-day production and the 500,000-bbl-a-day Abadan refinery. Tankers moved to other supplies, and consumers didn't notice the difference.

In 1956, President Nasser of Egypt closed the Suez Canal, and tankers either plied around Cape Hope or came to the Western Hemisphere. The chief reaction — so far as oil operations are concerned — was the biggest boost in ship building the world has ever seen. For the first time, a 100,000-ton tanker was ordered. And every country with ship-building facilities had orders for years ahead.

Plans for future transportation have brought out the old blueprints of a pipeline from the Middle East to Europe and Israel has proposed the use of the Gulf of Agaba and a pipeline inside its borders, from the Port of Eilat to the Mediterranean Coast.

Another reaction is strengthened determination by companies in the Western Hemisphere to find and develop supplies in the Americas. Every country with an operative oil law for outside capital is getting a share of foreign investment. United States companies that have never operated outside the United States are going to Alaska, Canada, and to Central and South American countries.

This search, however, is hope for the future — perhaps 18 years in the future, as in Nigeria.

In spite of disrupted transportation routes the petroleum industry did not pause in its advance to impressive new records. Both production and refining capacity scored an 11 percent increase over 1955.

Crude oil production rose 10.7 percent to 6240 million barrels in 1956. Bureau of Mines total for 1955 was 5634 million bbl. Except in a very few cases, the figures for each producing country given below are average barrels per day. Total output in 1956 was 16,609,231 b/d.

Refining crude oil capacity for the world is an estimated 18,642,924 b/d. Largest inoperative capacity remains Abadan, which before nationalization had a 500,000 b/d capacity but last year ran less than half of this amount. The enormous total of refining construction in progress is evident in the sketches below.

TENTH ANNUAL ROUND-UP OF WORLD OIL ACTIVITIES

ADEN

R. C. 100,000 b/d

Aden Petroleum Refining Ltd. has been changed to BP Refinery (Aden) Ltd. The company is adding a 12,000 b/d thermal reforming unit to increase production of high grade motor gasoline at the Aden refinery. Cost is estimated at $1.4 million and date of completion is early 1958.

In the British group of Kamaran Islands where British Petroleum Company, Ltd., obtained an exploration license at the end of 1955, geological and gravity surveys have been completed.

AFGHANISTAN

Drilling began June 11, 1956 by Swedish Diamond Drilling Company on behalf of the Afghan Government on the Angut anticline. It went to 2680 ft and had some oil shows. The site was at Sar-i-pul in the extreme northeast, 80 miles from the USSR border and some small Soviet oil fields. The second well is now underway.

ALASKA

Exploration for oil and gas by private enterprise in Alaska continued at an increased rate in 1956. Ten major oil companies and many smaller ones have been active in conducting reconnaissance, filing lease applications, entering into unit or development agreements with the Secretary of the Interior, and actually drilling in the search for oil and gas. Major companies active are General Petroleum, Humble Oil, Ohio Oil, Phillips Petroleum, Richfield Oil, Shell Oil, Standard of California, The Texas Company, Union Oil, and Sunray Mid-Continent.

Phillips Petroleum completed its second test in the Icy Bay area to a depth of 10,000 ft. No oil or gas discovery was reported. A third test is drilling below 9000 ft only 1200 ft away from Sullivan Strat No. 1. An extension of time has been granted this company in the Katalla section where drilling was started in 1956. Phillips has also acquired 50,000 acres on the Kenai Peninsula.

Standard Oil Company of California continued its geologic reconnaissance in several sections of the Territory and acquired leases in the Katalla area and on the Alaska and Kenai Peninsulas.

Shell has also acquired leases on the Alaska and Kenai Peninsulas and continued field reconnaissance activities.

Richfield, Union, and Ohio oil companies have entered into a unit agreement covering 71,680 acres on Kenai Peninsula. Drilling is to begin early in 1957.

Colorado Oil and Gas Company has conducted extensive seismic and gravimetric surveys with full-time helicopter support on 1,200,000 acres near Yakutat. A tentative test site has been selected, and drilling is to commence early in 1957.

Iniskin Unit Operators, representing the Havenstrite Oil Company of Los Angeles, conducted detailed logging of a test in Iniskin Bay to a depth of 9745 ft. Operations have been temporarily suspended.

Alaska Oil and Gas Company and Aledo Oil Company in a joint venture deepened a Nelchina test with a cable rig to 4820 ft. Aledo proposes to bring in a rotary rig for drilling to greater depth.

Anchorage Gas and Oil Development drilled a third shallow stratigraphic test in the Houston area. One of these tests is now at 3880 ft.

Texota Oil Company and Brooks-Scanlon Oil Company jointly conducted geologic reconnaissance in the Kateel River area of the Koyukuk Basin. Applications for leases covering 1½ million acres have been applied for in this area.

ALBANIA

Prod. 7000 b/d **R. C. 7000 b/d**

The basis for estimates of production and refining are reports that the Cerrik plant has gone on stream. Production is indicated to be about 7000 b/d and the announcement of the new plant stated all output could be refined locally.

A pipeline runs from Stalin field, Albania's largest, to the new refinery.

The 1955 Five-Year Plan calls for 10,000 b/d production in 1960.

ALGERIA

Prod. 1600 b/d

Exploratory activity in Northern Algeria has gone down as that in the Sahara increases.

Production of Oued Guétérini, Northern Algeria, has dropped steadily, producing 670 b/d as against 1150 b/d in 1955.

In the Sahara, exploration has been pursued by four companies holding permits: Société Nationale de Recherche et d'Exploration des Pétroles Algerie (SN REPAL) and the Compagnie Francaise des Pétroles Algerie (CFPA) in the northern part; Compagnie des Pétroles d'Algerie (CPA) and the Compagnie de Recherches et d'Exploitation des Pétroles au Sahra (CREPS) in the southern part.

At the year's end, they were using 18 drilling rigs and 19 geophysical teams (of which 15 are seismic crews).

In North Sahara, at Hassi Messaoud SN REPAL discovered oil at 10,826 ft.

The company also found important gas shows at Hassi R'Mel wells between Laghouat and Ghardaia.

CRESPS has pursued an intensive exploration program.

CFPA found oil shows in Metlili.

ANGOLA

Prod. 400 b/d

Purfina-Lobito (Petrofina) ships oil from its recent oil discovery near Bemfica to Lisbon for processing in SACOR's plant there.

The new field is reported to be a large structure and Petrofina expects to develop it. Three wells have already been drilled to limestone of the lower Cretaceous at 9000 ft.

Another structure at Luanda also located by seismic work had just been discovered at the end of the year. Two wells have been drilled and tests are promising.

ARGENTINA

Prod. 90,000 b/d **R. C. 200,000 b/d**

With consumption nearing 220,000 b/d despite some restrictions, the cost of importing more than 60 percent the required oil continues to rise. It was $200 million in 1956. The new government, instead of granting concessions to foreign companies, decided to bolster the state-owned YPF with capital for expansion.

Transport has been a crucial problem. Plans for pipeline construction of the Peronista regime are still to be realized. Some $250 million is sought for needed pipe and drilling equipment. An 800-mile crude oil line is scheduled from Salta to San Lorenzo on the River Parana and a 1000-mile gas transmission line from Salta to Buenos Aires, and a 500-mile crude oil line from Mendoza to San Lorenzo.

YPF had 56 rigs running in 1956.

YPF's six refineries have 138,500 b/d capacity. Esso has four plants with a total of 33,500 b/d capacity and Shell has one at Buenos Aires with 21,000 b/d which is running 22,500 b/d.

AUSTRALIA

R. C. 190,000 b/d

Structure holes are being drilled near Exmouth Gulf, stratigraphic tests have been drilled in the Kimberley district, and a T-20 rig has been shipped to Dirk Hartog Island, off the northwest coast, where a test well is proposed. These are operations of West Australian Petroleum Pty. Ltd. (Caltex 80 percent — Ampol 20 percent), which holds exploration permits over 282,000 sq. miles.

It was in the Exmouth Gulf area at Rough Range where oil was found in December, 1953.

The Middle East supplied 77 percent of the crude in 1955, and 69 percent in 1956. Even with present enlarged refining capacity about 25 percent of oil products needs must be imported.

Bitumen and Oil Refineries Ltd. have abandoned plans for enlargement of the Queensland refinery. A 1500 b/d Platformer and a 1500 b/d desulfurizer are being added to New South Wales refinery at Matraville.

A new catalytic reformer will be added to the British Petroleum refinery at Kwinana, Western Australia.

Australian Oil Refineries at Kurnell, New South Wales, is increasing its refinery capacity to 30,000 b/d.

Field parties for Stanvac carried out 20 party months of geological work and 11 party months of gravimetric work. The Standard-Vacuum refinery at Altona ran 28,800 b/d. Early in the year, completion of an alkylation plant enabled Altona to start the manufacture of high grade aviation piston-engine fuels.

AUSTRIA

Prod. 68,000 b/d **R. C. 45,600 b/d**

Under amended terms of the 1955 Peace Treaty with the USSR, Austria must send 26,000 b/d to Russia. Because of fuel oil shortage, the Soviet was asked to accept dollar payments in place of some crude oil.

Consumption rose 22% to 32,000 b/d in 1955 and indications are for another large increase in 1956.

What may be an extension to Matzen field in Lower Austria was discovered last year and the area is being tested by further drilling.

A newly formed government-owned company, Oesterreichische Mineralol Verwaltung A.G., has taken over all petroleum operations.

BAHAMAS

Bahama California and Bahama Exploration (Gulf) continued exploration activities including seismic surveys on their jointly held 1700 square mile concession in the Cay Sal area. In addition, both companies hold concessions independently. Bahama National Oil Company and Sun Production Company were also granted concessions in 1956.

BAHRAIN ISLAND

Prod. 30,000 b/d **R. C. 205,000 b/d**

Bahrain, with its movies and broadcasting station, had reached the point of a national election when opposition to Britain and the local ruling family created demonstrations.

There is indication that Bahrain will quiet down and continue to be a showcase of Arab progress in the Middle East.

Production has remained at a steady level with planned drilling at Awali of about a dozen wells a year. Bahrain Petroleum Company (Caltex) will complete a 10,000 b/d Platformer this year.

Consumption is rising rapidly in the Sheikdom. It rose 30 percent in 1955 over 1954.

BARBADOS (BWI)

Barbados Gulf Oil holds a prospecting license over about half the Island of Barbados (north of Trinidad), which also extends into portions of the territorial waters adjoining.

First test, Gulf Turner Hall No. 1, was drilled to 11,352 ft but did not find commercial oil production. It was, however, completed as a gas well and sold to the Natural Gas Corporation.

Three other tests were not commercial although one had good gas shows. It had a TD of 12,178 ft. Gulf's fifth well, Gulf Friendship No. 1, reached 10,799 ft on November 27, 1956, when drilling was temporarily suspended.

British Union Oil, which has a prospecting license for the balance of the island, including some territorial waters, relinquished it in 1956.

BELGIAN CONGO

A second stratigraphic test at Dekese, province of Kasai, was dry at 6000 ft. Petrofina handles operations here for the government and other interests.

Consumption of gasoline, fuel oil, and lubricating oil runs about 6400 b/d in this Central Africa territory.

BELGIUM

R. C. 138,000 b/d

Petrofina has the only exploration license in Belgium. It is near the Netherlands border.

BP and Petrofina are adding an 8000 b/d Hydrofiner and a 7000 b/d catalytic reformer to its 60,000 b/d refinery. Esso Standard is building a 5600 b/d cyclic Powerformer. A 2500 b/d cat reformer and desulfurizer is being built by Raffinerie Belge de Petroles, S.A. All three refineries are in Antwerp.

Consumption in Belgium continues at about 80,000 b/d oil products. Some fuel oil shipments come from Russia.

BOLIVIA

Prod. 8500 b/d **R. C. 12,300 b/d**

During the year, Gulf Oil signed an agreement with the Bolivian government for petroleum exploration and development in Bolivia through a subsidiary.

Under the agreement, Gulf acquired exploration rights for 3,750,000 acres within the reserve held by the Bolivian government's oil agency, YPFB. The firm has the right to select within four years 1,125,000 additional acres on which it will have exploitation rights for 40 years.

Bolivian Gulf will pay the Bolivian government 11 percent royalty in oil for production plus a 19 percent exploitation tax. In return, Bolivian Gulf is to help finance a 201-mile pipeline from Sicasica, Bolivia, to the Pacific Coast port of Arica, Chile, at an estimated cost of about $5 million.

Several other large oil companies were negotiating with the Bolivian government for oil concessions at the end of the year.

During the year, the Bolivian government extended the time for development on the 970,000-acre concession held by Glenn McCarthy, Texas oil man.

The Congress, in 1956, ratified the Bolivian oil code, which specifically is designed to attract foreign investment in the Bolivian fields.

YPFB brought in several additional wells during the year and total production increased about 1000 b/d.

YPFB has 11 rotary rigs. Beginning this year it will start supplying gasoline to the southern cities of Peru. The agency is headed by Juan Luis Gutierrez Granier, who succeeded Jose Paz Estenssoro, brother of the former president of Bolivia.

BORNEO (British)

Prod. 115,900 b/d **R. C. 47,000 b/d**

Brunei. Seria field produces 114,500 b/d of British Borneo's oil. Output of British Malayan Petroleum (Royal Dutch-Shell) has increased steadily since World War II.

Some 45 wells were drilled in 1956 with 7 to 8 rigs operating. Following discovery at Perudong in 1955 a number of appraisal wells were drilled with negative results. The first test from a high seas platform was spudded-in early in November. The platform is on the Ampa Patches structure some 25 miles off the coast in 30 ft of water. There are now six platforms off the coast of British Borneo.

Sarawak: Miri field contributed another 1400 b/d to production. Sarawak Oilfields Ltd. is in the course of erecting a marine drilling platform 8 miles off the coast of Sarawak and some 60 miles SW of the Ampa Patches platform mentioned. Refinery runs at the Lutong Plant are running about 51,000 b/d.

North Borneo: Shell Co. of North Borneo Ltd. is searching for oil inland and offshore.

BRAZIL

Prod. 25,000 b/d **R. C. 124,000 b/d**

Brazilian consumption of petroleum amounts to an annual value of $320 million dollars from which $66 million correspond to local production.

Production was increased by the end of 1956, being now 25,000 b/d.

At Mataripe, Petrobras is expanding its present refinery capacity, from 7000 b/d to 37,000 b/d, including 3000 b/d lub oil and wax production facilities.

A new 90,000 b/d refinery is planned.

Several petrochemicals plants are being erected by well-known organizations (Carbide, Kopper, Firestone, Celanese, etc.)

BULGARIA

Prod. 1000 b/d (?) **R. C. 7300 b/d (?)**

The Bulgarian government is buying back Gorubso, its own mining and oil monopoly, from USSR by payments made from production.

Oil comes from a small field near Romania in northwest Bulgaria and is refined at Varna on the Black Sea Coast. This and three skimming plants comprise all the refining capacity.

BURMA

Prod. 4000 b/d **R. C. 2900 b/d**

Seismic survey operations by Burma Oil continue in the Irrawaddy delta. Location has been made for a 10,000-ft test at Ondwe on the banks of the Irrawaddy. The first well will search for gas to power the boilers for the steam rig that will make the deep test. In the Chauk and Lanywa fields 15 wells were completed. The two fields produced 3812 b/d. Presently refining is at Chauk and the Syriam 4000 b/d plant is being reactivated.

In the local company Assam Oil (Burma Oil) owns two-thirds and the state owns one-third. This company handles most oil operations except marketing.

CAMEROONS

Shell-B.P. Petroleum Development Company of Nigeria is to make a geological survey of the southern part of the British Cameroons. This area extends into Nigeria from the East.

SEREPCA is drilling some tests in the French Cameroons, on the west of French Equatorial Africa. This company dis-

covered a gas field at Logbaba, near Douala in the Cretaceous, Upper Eocene.

CANADA

Prod. 470,000 b/d R. C. 710,000 b/d

Exploration and development continued at a record rate in the four western provinces, with greatest activity in the foothills area of Alberta, southeastern Saskatchewan and northeastern British Columbia. Survey activity was extensive throughout Western Canada, with an estimated total of 1717 crew months worked. Some 300 rigs drilled in excess of 3200 wells in Western Canada during the year.

Canada's crude oil production in 1956 increased approximately 32 percent over the previous year.

Exports of crude oil increased in excess of two times over 1955, approximately 114,000 b/d. Of the crude oil exported, 84 percent has been from the province of Alberta, the remainder from Saskatchewan. The principal export areas were the Puget Sound and Lakehead-Minneapolis regions of the United States. Offshore shipments increased substantially during the year, primarily to the California coast. However, a few shipments went to Japan.

An estimated 223 million barrels of crude oil were used by Canadian refineries during 1956. This showed an increase of over 15 percent of the previous year's consumption. Of this, Canada supplied 54 percent — the remainder being imported from Venezuela, Near and Middle East, United States and Trinidad.

The Canadian demand for crude oil and products in 1956 is estimated at 705,000 b/d. This is an increase of approximately 12 percent over 1955.

The Trans-Mountain oil pipeline recently increased its capacity to 184,000 b/d. By mid-1957, it is expected that the capacity will be up to 240,000 b/d.

Interprovincial oil pipeline extends some 1774 miles from Edmonton, Alberta, to Sarnia, Ontario. Its 1956 throughput was some 97,155,875 bbl.

At the year's end Westcoast Transmission Company's line, running from northeastern British Columbia, to link with the Pacific Northwest Pipeline Corporation to supply British Columbia centers and northwest United States, was 70 percent completed. Trans-Canada Pipeline, running from the Alberta-Saskatchewan border to Eastern Canada has completed half its stretch from the Alberta-Saskatchewan border to Winnipeg, Manitoba.

Of progressive significance regarding transmission systems during 1956 was the completion of the Westspur pipeline in July, which carries crude oil from southeastern Saskatchewan to the Interprovincial pipeline; and also the completion of the Cremona pipeline, which carries crude oil from the Sundre-Westward Ho area to the refineries in Calgary, Alberta.

Refinery capacity in Canada increased by some 90,000 b/d to a total capacity of approximately 710,000 b/d. The major factor contributing to this increase was the 24,000 b/d increase in Imperial Oil's Halifax refinery. Cities Service is planning a 20,000-25,000 b/d refinery in the Port Credit area of Ontario.

CEYLON

Shell, BP, Stan-Vac and Caltex are jointly interested in building a refinery in Ceylon, the island republic south of India. This would allow domestic processing of the 17,000 b/d products consumed.

CHILE

Prod. 10,400 b/d R. C. 20,700 b/d

Chile's production doesn't come close to its 38,500 b/d consumption of oil so the state monopoly, Empresa Nacional del Petroleo, is making every effort to increase reserves. Exploration this year went into the northern province of Tarapaca for preliminary surveys. So far exploration has been concentrated in the southern province of Magallanes where four geological, two gravity and three seismic crews continue working.

A new law has been drafted to allow private capital to explore and develop oil resources. At present only ENAP can operate in the entire nation. The company has one 20,000 b/d refinery at Concon and a natural gasoline plant at Magallanes.

CHINA (Communist)

Prod. 13,500 b/d? R. C. 15,000 b/d?

Ministry of Petroleum Industry reported 19,300 b/d crude oil production in 1955 (which doubtless includes shale oil). It was expected to be about 30,000 b/d in 1956. In 1954 Pravda indicated petroleum was about 45 per cent of China's total "oil" production which gives us the above vague figures.

From numerous reports of exploration by Chinese, by Hungarians, and others, there is evidently a feverish attempt to build up reserves. More than 200 geological, geophysical and drilling crews are working, even in northern Tibet and in the Gobi desert, it is reported.

The Yumen area, in eastern China, largest producing region, has new railway transportation which allows larger output. Reportedly another reserve has been found in northern Sinkiang estimated to be larger than the biggest Yumen field.

COLOMBIA

Prod. 120,300 b/d R. C. 46,500 b/d

In a new decree in Colombia's petroleum laws, if a contract for an exploration concession is not signed in 90 days after application is approved the area can be offered to others.

Despite difficulties and costs connected with exploration and drilling, because of the heavy jungle, work is going ahead. Mobil Oil of Colombia went to 13,107 ft at Chagui*, near Cali, after spending 20 years studying the area. Cost of the well was $2 million and it was dry.

Applications for concessions in the Llanos, the eastern plains, have been received from Royal Dutch-Shell, International (Jersey), and Socony. Exploration will be costly in this inaccessible region but if oil is found the government's share is limited to 40 instead of 60 per cent.

Richmond (Standard of California) is active in northern Colombia. Seismic surveys, core-hole drilling, and geological studies were undertaken on its concession. One exploratory well was drilled, which discovered a gas field.

Empresa Colombiana de Petroleos, state-owned company, contracted with Forest Colombian Corporation (Forest Oil) to waterflood La Cira field in the De Mares concession, which reverted to the government in 1951. Parsons made an engineering study prior to modernizing the gasoline plant on the concession.

Three wildcats were drilled, two dry and one a small producer, which will be sand-fractured. Twenty-one wells were drilled in Infantas and Colorado fields, making a total of 1118 producers in De Mares. Production reached a new record of 31,531 bbl of oil and condensate (2155 b/d from gasoline plants).

* The Flying Red Horse, Autumn, 1956, Company magazine of Socony-Mobil Oil Co.

Another move by the government firm was to go into a $20 million offshore venture with John W. Mecom, Houston. Like the Colombian Cities Service contract the company holds 75 per cent interest and Ecopetrol 25 per cent.

Texas Company's Velasquez field has leaped to 20,000 b/d output from 3526 b/d average in 1955. The new pipeline to Andian line at Galan permitted the rise.

Colombian Petroleum Company (Socony and Texas) is building a $5 million gas processing unit.

Intercol has a $32,500,000 refinery under construction at Cartagena. It will have 28,000 b/d capacity and will go on stream this year.

An Intercol affiliate completed a 62-mile, 8-in. products line from the port of Buenaventura to Cali in 1956. Cost was about $5.4 million.

Consumption runs about 40,000 b/d and continues to increase.

COSTA RICA

Prod. 300 b/d

For the first time Costa Rica has become an oil producer. Union Oil Company of California, which has explored the Central America Republic since 1952, completed an important oil discovery on its 3,500,000-acre concession in 1956. Concoles No. 2 flowed at a top rate of 1000 b/d. Total depth is 4950 ft. The location is near the Panama border and another well will be drilled on Union's 350,000-acre concession in Panama.

CAICOS ISLAND (Br.)

(See Turks Island)

CUBA*

Prod. 1488 b/d R. C. 39,200 b/d

Atlantic Refining did a limited amount of exploratory drilling in Camaguey province under farmout arrangements made with other companies. Seismic work was initiated in Pinar del Rio Province in June 1956 and was continued there for the balance of the year.

Cuba California Company continued geological and geophysical surveys over its holdings in the north coastal area.

Cuban Stanolind Oil (Pan American Petroleum) completed aerial photography and airborne magnetometer work on some 12 million acres of on- and offshore lands. The firm acquired rights on an additional 3 million acres, principally in Oriente province, from Trans Cuba Oil and Cuban Venezuelan Oil Voting Trust; these are the same firms from which Cuban Stanolind obtained its original acreage. An exploration option on about 1,400,000 acres in five blocks was worked out with White Eagle International Oil Company. Cuban Stanolind drilled No. 1 Los Chivos, in Oriente province which was abandoned at 5469 ft. A second well is drilling.

Refining capacity was more than tripled from 10,700 b/d in 1955. It will go to 85,000 b/d in 1957. Esso is expanding its Belot plant near Havana to 35,000 b/d crude capacity with new Hydrofining, Power-forming, catalytic cracking and catalytic polymerization units.

The Texas Company's $14 million Santiago plant, with 20,000 b/d capacity, will be completed this year.

*More detailed review coming next month.

CZECHOSLOVAKIA

Prod. 5000 b/d? R. C. 14,000 b/d?

The new refinery near Bratislava will not be on stream until 1958. Information last year indicated it was already completed and had a capacity of 20,000 b/d.

Production comes from small fields near Austria. In the Five-Year Plan liquid fuels production was reported at 16,000

b/d in 1955. Most of this is evidently from coal synthesis.

DENMARK

R. C. 750 b/d

Jersey Standard took over Gulf Oil's exploration concessions here and expects to begin drilling soon. Gulf was unsuccessful in its long search.

Consumption runs almost 55,000 b/d.

DHOFAR (Arabia)

Dhofar-Cities Service drilled three test wells, two of which encountered oil shows. Two drilling rigs are scheduled to operate starting with the second quarter of 1957. Richfield has a 50 percent interest.

DOMINICAN REPUBLIC

A new law states foreign concerns may not develop oil and gas resources.

ECUADOR

Prod. 9500 b/d **R. C. 6050 b/d**

Production in Ecuador is less than a fourth of the rising consumption. One trouble is that product prices are set by the government and companies take losses on such volume products as gasoline.

Production area is the Santa Elena Peninsula where Anglo-Ecuadorian has 320 sq. miles under concession. Manabi Exploration has a small (1500 b/d) output. California Ecuador Petroleum Company carried on a general exploration program in the coastal area where it has concessions covering some 3,500,000 acres.

The two refineries are at Santa Elena also: Anglo-Ecuadorian's 5600 b/d plant and Manabi's 600 b/d refinery. No action yet on the Anglo-Ecuadorian plant to be built on contract from government.

EGYPT

Prod. 33,000 b/d **R. C. 90,000 b/d**

The most favorable sign in the Egyptian economics picture right now is prospects of large oil resources. If present exploration could double production, it would fill domestic consumption.

In the last two years Sahara Petroleum (Conoco, operator, Ohio, Cities Service, and Richfield) has spent $15 million exploring on its 50-million-acre concession. Its first test, 28 miles southwest of Alexandria, went to 13,300 ft and was abandoned July, 1956 as dry. A second one, 60 miles southeast of Alexandria, was abandoned in July also after drilling to 13,388 ft. Three others are now drilling.

Sahara continued the operation of three seismograph crews and for the first six months of the year operated one gravity meter. The company operated eight surface geological parties.

In November, 1956, all expatriate personnel and their families were evacuated as a result of the Israeli and Anglo-French invasion. Drilling operations on the three exploratory wells were suspended and all field exploratory operations also were suspended. At the end of the year State Department approval had been received to return the expatriate personnel to Egypt and operations were being reactivated.

Anglo-Egyptian Oilfields (Royal Dutch Shell) did some drilling in its Ras Gharib field, on the east coast of the Gulf of Suez. Fields on the Sinai peninsula of Anglo-Egyptian and Mobil Oil Egypt still produce.

International Egyptian (Petrofina, AGIP et al) was developing its new Belaim and Feiran fields. It has been reported that this field promises to be the largest in the country.

Before the Suez shutdown a petroleum bureau was set up under Ministry of Commerce. Plans were made to open 131 sq miles to oil concessions. The bureau runs the government refinery at Suez. A small plant (4000 b/d capacity) was transferred from Switzerland to Alexandria by Societe Egyptienne de Petrole, (Caltex distributors). "SEP" is owned by Ominium (French).

Anglo-Egyptian's Suez refinery, with capacity of 44,000 b/d averaged about 39,500 b/d throughput. The government's Cairo plant should have gone on stream the last of the year. Its rated capacity is 46,000 b/d.

A 12-in., 80-mile products pipeline from Suez to Cairo was completed.

ETHIOPIA

Sinclair completed six stratigraphic exploratory wells in the Ogaden area.

FINLAND

Neste Oy, state-owned oil company, is building a 19,000 b/d plant at Naantali in the southwest. Lummus Company is doing designing and supervising. Constructing is done by Cie de Fives-Lille, Mannesmann-Seiffert Rohrbau GmbH, and Neste Oy.

Consumption in 1956 increased to about 33,000 b/d.

FORMOSA (TAIWAN)

Prod. 2890 Mcf/d
67 b/d **R. C. 18,500 b/d**

Exploration surveys by the Chinese Petroleum Corporation were continued during 1956 with seismic surveys, and geologic surveys supported by micropaleontological and sedimentation laboratories that are now operating at full scale.

Exploration drilling extended the productive area and proved a deeper productive zone at the Chutouchi South Culmination, but shallow wildcat tests on two anticlinal structures, and an extension well at the small Shantzechiao field discovered in 1955, were unsuccessful.

Since no development drilling was undertaken, production for 1956 still remained low at 21,116 bbl of crude, 3430 bbl of natural gasoline, and 1,055,984 mcf natural gas; of this total, 43 per cent of the crude and 18 percent of the natural gas were contributed from exploration wells completed during the past three years that are now on production or being tested. The proving of additional reserves, mainly of gas, at the Chutouchi South Culmination field discovered in 1954, may lead to increase in production during 1957.

The Chinese Petroleum Corporation's new 6500 b/d TCC unit is now in operation at the Kaohsiung refinery.

FRANCE

Prod. 25,285 b/d **R. C. 622,000 b/d**

Exploration has been intense in all the sedimentary basins of France, now practically covered with applications or permits. Twenty companies are now active, among which are seven from other countries (Esso-Standard, Caltex, British Petroleum, Socony-Vacuum, Shell).

Thirty rigs are active. A total footage of 572,946 ft and 64,438 core-drill tests have been drilled. Production rose from 17,289 b/d of oil in 1955 to 25,285 b/d in 1956, an increase of 36 percent.

This increase is due especially to the development of the Parentis oil field, discovered in 1954 by Esso-Standard, in the Aquitaine basin, 40 miles S-SW of Bordeaux. Out of the 25 wells drilled since the discovery, 21 were producers. Production of the field increased to more than 22,800 b/d in October 1956 and was raised to 25,726 b/d in December 1956 because of Middle East events. Yearly production rose from 4,267,300 bbl in 1955 to 7,377,454 bbl in 1956.

On the Mothes structure, eight miles East of Parentis, Well No. 1, productive in August 1955, produced steadily in 1956, 300 b/d from the same Neocomian reservoir as Parentis.

Other structures in the vicinity of Parentis, in the Esso-Rep exploratory permit, proved to be productive, although difficult to develop. Lugos 1, 13 miles NW of Parentis 1 well, hit oil at 5,300 ft and gave about 300 b/d of good oil by pumping. Lucats 1, five miles SE of Parentis 1 was in production by pumping at the end of the year at 6850 ft.

In the Société Nationale des Pétroles d'Aquitaine permit, on the Pyrenean foothills, production of the Upper Lacq oil field decreased from 1,669,000 bbl in 1955 to 1,194,885 bbl in 1956. Reserves of the deep Lower Lacq gas field were considerably increased. Production of this big gas field is planned to start in 1957.

In the Paris basin, in spite of some deep wells drilled to the basement, no production was established. In the Rhine graben, PREPA is developing some small oil fields but its production decreased from 148,246 bbl in 1955 to 136,104 in 1956. In the Rhone Valley, Société des Pétroles de Valence (BP) started exploration and drilled its first well with some oil shows.

Refinery expansion projects will bring total crude capacity to about 710,000 b/d in 1959. At Dunkerque and Lavera, BP will increase its refining capacity from 84,000 b/d to 140,000 b/d. Esso plans to build a 30,000 to 40,000 b/d refinery near Bordeaux to process Parentis crude.

In spite of Suez events, crude oil for refining, an average of 530,000 b/d, came principally from the Middle East.

FRENCH EQUATORIAL AFRICA

Prod. 200 b/d (?)

Societe des Petroles d'Afrique Equatorial Francaise (government-owned) discovered oil in the Gabon Basin in 1956 after a long exploration program. The first tests were drilled in 1949.

One small field was found at Ozouri in the Eocene. Another at Pointe Clairette near Port Gentil has three pay sands, two in the Eocene and one in the Upper Cretaceous. The latter has four wells producing from below 4000 ft and looks promising. Three rigs are in operation. Both finds are near salt domes. The wells produce 350 to 750 b/d.

The Gabon is a sedimentary basin of about 11,000 sq miles.

FRENCH WEST AFRICA

In Senegal, two new companies, La Société Africaine des Pétroles and Société des Pétroles du Senegal, have undertaken explorations in the principal Cretaceous structures.

Three seismic teams and three drilling rigs operated in that region last year.

GAMBIA

British Petroleum obtained an exploration license in this British colony and protectorate at the end of 1955 and carried out a water-borne seismic survey of more than 200 miles of the River Gambia. Bureau de Recherches de Petrole and British Petroleum are carrying out a seismic survey on a 50-50 basis with British Petroleum as operator.

GUATEMALA

So far 24 companies or individuals have concessions in the Central American Republic of Guatemala*. Several U. S. companies have established offices in Guatemala City and geological and geo-

physical crews are busy in Peten and Izabal, in the north. Where applications for concessions overlapped compromises were worked out in 1956.

*See "Three Stories of Guatemala," by Ernestine Adams, The Petroleum Engineer, November, 1956, Page E-7.

GERMANY (West)

Prod. 72,100 b/d R. C. 300,000 b/d

It speaks well for Western Germany's progress in oil and gas operations that the Suez crisis brought no rationing. Professor Erhard, Federal Minister of Economics, agreed with the petroleum industry that no purpose could be served by Federal interference.

The nation was doing well. Oil production went up 11.4 percent; natural gas soared to 53 percent above 1955. Consumption went ahead by about 25 percent. Refining capacity gained more in quality than volume.

As result of an intensive drilling campaign with a total footage of 2.3 millions from which about a half fell to exploration wells, 11 new oil deposits were discovered in 1956, the majority of which, however, seems to have minor economic value only. The newly discovered fields were: Schwedeneck in the province of Schleswig-Holstein; Elsfleth, Ortland, Harme and Oythe in the oil district between the Weser and Ems rivers; Eilte-West, Leiferde, Hoever and Rietze in Hanover and Huttenheim and Minfeld in the Upper Rhine Valley.

Expansion of the oil refining industry was mainly concentrated to the addition of Platformers and Hydrofining units. Some major new projects were announced. Standard Jersey intends to build a refinery with an initial crude intake capacity of 60,000 b/d at Cologne (Rhine) which is scheduled to start operations in 1959.

Shell, which is just installing a second Platformer and a hydrodesulfurizer in its Hamburg-Harburg refinery, plans to erect a new refinery at Wesseling-Godorf, south of Cologne, which in the first stage will go on stream at the end of 1960 with a crude capacity of 70,000-80,000 b/d.

BP is increasing its plant at Hamburg-Finkenwerder to 40,000 b/d and has also projected a new refinery in the main consumption center of Germany, the Rhine-Ruhr-district, with a capacity similar to that of the Esso and Shell plants.

A fourth project was just published by the S.A. Petrofina, Brussels, which expects to build a mineral oil treating plant at Duisburg with 20,000 b/d, later to be stepped up to 60,000 b/d.

Socony Mobil just completed a 3200 b/d Platformer and a 5000 b/d hydrodesulfurization unit at Bremen-Oslebshausen. On the refinery of the Gewerkschaft Erdöl-Raffinerie Emsland at Lingen a 3000 b/d Houdriformer was completed.

GERMANY (EAST)

Prod. 10 b/d R. C. 2000 b/d

Most East Germany refining is coal liquefaction plants. It amounts to about 38,000 b/d.

GHANA (GOLD COAST)

A second test, Epunsa No. 1, on the coast and six miles west of Half-Assini, was spudded near the end of 1956, by Gold Coast Gulf Oil Company, which holds two exploration licenses in this former British territory. The first test well went to 10,669 ft and was abandoned.

The Gold Coast has become a self-governing Dominion and is known as Ghana.

GREECE

Greece's first refinery, government-owned, will be ready to go onstream in late 1957 or early 1958. It will have 30,000 b/d capacity.

American-Grecian Oil Company has acquired a concession covering the island of Zante, west of the Peloponnese.

Since 1952, Deilmann Bergbau G.m.b.H has been carrying out exploration work for crude oil and natural gas in Greek Thrace in cooperation with the Greek company SUN Mine and Oil-Bed Exploitation S.A. (ILIOS). Investigations concentrate on the eastern part of this area, near the Turkish frontier. After detailed geologic, gravimetric and reflection seismic exploration, the first exploration well, Ardanion 1, was drilled in 1956, reaching a total depth of 7624 ft and encountering oil and gas indications at various horizons. Commercial production, however, could not be achieved. Another exploration well is in progress.

HAITI

Commonwealth Oil Company holds the concession in Haiti.

In 1956 there were two dry holes drilled, both on the island of Gonave about 50 miles off the coast. These wells were drilled by John Mecom, M. E. Andrews, Ltd. and Commonwealth Oil Company. The No. 2 well reached a total depth of 8001 ft and the No. 3 reached 6976 ft. The No. 1 was drilled to 2741 ft in 1955.

No wells were drilled on the mainland but Commonwealth was engaged in geological exploration on the mainland during the entire year.

HAWAII (U. S. Territory)

R. C. 3000 b/d

Standard of California owns only refinery at Honolulu. The company has applied to construct a 26,000 b/d refinery.

HONDURAS (British)

British Honduras Gulf Oil drilled two dry holes and expects to continue exploration work.

HUNGARY

Prod. 30,000 b/d (?) R C 25,000 b/d (?)

A shortage of oil was reported in the fall. Production at Nagylengyel field, near Lake Balaton, is said to have dropped alarmingly.

This may affect construction of the new refinery at Szoeny, which was to process the heavy crude from Nagylengyel.

Gas production is estimated at 10½ million cubic feet a day.

INDIA

Prod. 7878 b/d R. C. 87,100 b/d

Assam Oil Company (Burmah Oil) completed seven party months of reflection seismic work in Upper Assam and 12 wells around Nahorkatiya during 1956. Of these, nine are potential producers, one a gas well, and one dry hole. Most of the wells were drilled to about 10,000 ft but one was drilled to 13,053 ft before being plugged back for production test.

Assam Oil completed Moran No. 1 at 13,739 ft, deepest well in the Indian subcontinent. It found a productive sand at about 11,000 ft and this is being followed up by extension wells, one of which was drilling at the end of the year.

Development drilling continued in Assam' Digboi field.

Wellhead production from Digboi, Nahorkatiya and Moran was 2,875,685 bbl, compared with 2,526,103 in the previous year from Digboi and Nahorhatiya.

Government planners expect to stress oil exploration. A Canadian team assisted with an air-magnetic survey in the Northwest. Russian technicians recommended exploration and test drilling in the Punjab and in the Ganges Valley in West Bengal. The government acquired a Rumanian rig and Rumanian experts have been hired to operate it. The government bought three drilling rigs from Russia and USSR technicians will operate them and teach Indian crews.

Seismic exploration is continuing in Standard-Vacuum's Bengal Basin concession. In addition, two gravimetric parties entirely staffed by Indian personnel were in the field for an aggregate of 19 months during 1956. Crude capacity of Standard-Vacuum's Bombay refinery went to 28,200 b/d. The cat poly plant was started in mid-year.

Caltex's 13,500 b/d refinery at Vizagapatmam will go on stream this year.

Negotiations continued during the year between the Government and Assam Oil Company regarding formation of a new company to develop Moran, Hugrijan and Nahorkatiya concessions. A committee has also considered the alternative sites for a new refinery as it is estimated that the new fields will be capable of producing 50,000 b/d.

INDONESIA

	Prod. b/d	R. C. b/d
Sumatra	226,000	167,000
Java	9,700	7,800
Kalimatan*	18,700	56,000
	253,400	230,800

*Borneo.

Indonesia was plunged into more political confusion after the first of 1957 so averages above may suffer a decline.

Royal Dutch-Shell has fields in Southern Sumatra, Java, and Borneo. North Sumatra is still closed to the company by the government.

The Minas field of Caltex in Central Sumatra is the best in Indonesia, producing more than 80,000 b/d.

Standard-Vacuum's production in 1956 in Sumatra averaged 62,900 b/d. Field parties active consisted of one geological and one seismographic. Three exploratory wells were completed in Central Sumatra, one was drilling at year's end, and one drilled exploratory footage below known producing level. Two of these wildcats were successful.

In South Sumatra, three exploratory wildcats were completed and a fourth nearly so. None was an oil producer, although one was completed as a small gas producer. Forty-two development wells were completed during 1956, all but two being producers. In addition, six wildcats were drilled and three were producers.

Development of the Lirik producing field in Central Sumatra, including construction of a 90-mile pipeline to the Buatan loading terminal on the Siak River, progressed satisfactorily during the year.

Standard-Vacuum's refinery modernization at Sungei Gerong near Palembang is scheduled for completion and start-up operations in August, 1957. Refinery runs in 1956 averaged 61,600 b/d.

IRAN

Prod. 534,000 b/d R. C. 570,000 b/d*

Total net crude production of the Iranian Oil Exploration and Producing Company for 1956 in the Oil Agreement Area amounted to 195,580,000 bbl. About 69 percent of this production came from the Agha Jari field where drilling was resumed early in 1956. Wells No. 36 and No. 38 were completed as producers in this field at depths of approximately 6300 ft and 6800 ft, respectively. Work-overs

were continued at Lali, Haft Kel and Naft Safid.

A new 100,000 b/d production unit (No. 4 at Haft Kel) was commissioned in October, 1956. Seven wells are connected to the unit and the production from five more is to be fed into it when another unit is shut down.

To handle the increasing exports of crude oil, a fourth jetty was commissioned at Bandar Mashur, at the head of the Persian Gulf, in March, 1956 and pile-driving for a fifth jetty began in October. It is expected to be in use this summer.

Geological surveys of the Laristan coastal (Persian Gulf) area and Kerman district began in September west of Lingeh, and in November coastal structures were examined in the immediate vicinity of Lingeh. Topographical surveys were started near Ganoweh preparatory to a seismic survey in that region.

*Pre-1951 capacity for Abadan 500,000 b/d; present capacity has not been assessed.

The Iranian Oil Refining Company's throughput at Abadan Refinery amounted to 85,020,000 bbl in 1956. No new units were built but the systematic overhaul of all major units was continued throughout the year. A converted crude-to-gas line from Agha Jari to Abadan was put into use during the year and by November the consumption of gas at the refinery was averaging 28,350,000 cu ft a day.

Payments to Iran for 1956 amounted to over $152,000,000, including the value of oil supplied in lieu of cash payments.

IRAQ

Prod. 640,000 b/d R. C. 42,750 b/d

Syria agreed to allow Iraq Petroleum Company to repair its pipeline to Tripoli when Israeli troops left the Gaza strip early in March, 1957.

Iraq Petroleum Company paid $13,690,000 to Syria in January, 1957, for transit of oil through Syria in 1956.

The Ain Zalah and Butmah fields of the Mosul Petroleum Company suspended production for export in November. During December a small amount (27 tons) was produced for local use and this is shown in the year's cumulative total.

These three companies paid the Iraq government $192,640,000 under the 50:50 profit-sharing agreement.

IRELAND

Minister for Industry and Commerce accepted the joint proposal by California Texas Corporation, Esso Petroleum Company, Ltd., and Shell Mex & BP to erect and operate a 32,000-b/d oil refinery at Whitegate, County Cork.

The refinery will supply the entire needs of the country for major petroleum products, representing approximately 80 percent of the market.

Construction work is expected to take three years, so that the refinery should be "on stream" about the middle of 1959. It will cost about $34,000,000, which is the largest single U. S. investment in Ireland.

ISRAEL

Prod. 1000 b/d R. C. 85,000 b/d

One year after the first production of oil in Israel in late 1956, the Heletz oilfield was producing at the rate of 1000 b/d from eight wells. Six drilling rigs were operating in the Heletz field, and a semi-wildcat was being drilled about two miles south of the original Heletz strike.

During November, 1956, the first consignment of 18,000 tons of crude were sent through the Haifa refinery of Consolidated Refineries, Ltd., which was running at about 25 percent capacity.

Of nine companies engaged in oil exploration in Israel, five are wholly United States and/or Canadian owned, while three others have substantial U. S. interests. In all, 12 rigs were running at the end of 1956, one of them drilling a wildcat in the area of the Dead Sea.

Lapidoth-Israel Oil Prospectors group—joint licensees of the Heletz field—develops Heletz at the rate of about 15 wells a year.

Israel is building an 8-in. 115-mile pipeline from Eilat, its southern port on the Red Sea, to ease its dependence on Western Hemisphere oil. This pipeline, which is scheduled to put through its first oil in April 1957, will bring about half the country's crude requirements to the Haifa refinery.

ITALY

(Also see Sicily and Trieste)

Prod. 4000 b/d R. C. 491,000 b/d

In 1955 Gulf Oil, in association with Montecatini, an Italian firm, made a significant oil discovery near the Adriatic Coast. Early this year Gulf withdrew from all oil exploration activities in Italy.

The reason is a tight new oil law which virtually insures the state-owned Ente Nazionale Idrocarburi (ENI) sole oil exploration rights in the nation. There will be little, if any, competition. Only the extreme right wing parties voted against state monopoly of oil and gas resources.

The scale of royalties applicable to each well ranges from 2½ percent on 30 bbl a day production to 22 percent on production above 1800 b/d.

Cities Service subsidiaries have permits on acreage in Southeast Italy.

Most of Italy's 200,000 b/d consumption is imported crude oil processed within the nation.

ENI is adding a copolymer unit at its Ravenna plant to be completed this year. The BP and Azienda Generale Italiana Petroli refinery at Porto Marghera is installing a new platforming unit—the first in Italy.

A 5600 b/d powerformer is under construction at the Raffineria Garrone Genoa plant, and Stanic's refinery at Bari is building a 7300 b/d powerformer.

Golfo IP is building a 15,000 b/d plant at Gaeta.

JAMAICA

Jamaican Stanolind Oil Company (Pan American Petroleum) has staked its second test in the Cockpit area of Trelawny parish, about 16 miles south of Falmouth. The firm's first well, No. 1 Santa Cruz, which was the second oil exploration drilling venture on the island, was drilling below 7235 ft early in February. Jamaican Stanolind has prospecting licenses on the entire land area of Jamaica and on off-shore lands an average distance of 12 miles surrounding it. The firm acquired the licenses in 1955 in an agreement with Base Metals Mining Corporation, Ltd., and the Jamaican government. They cover an area of about 5.5 million acres.

JAPAN

Prod. 6048 b/d R. C. 370,000 b/d

Consumption of petroleum products increased to 237,000 b/d. Of this amount 204,000 b/d was refined domestically and 33,000 b/d was imported.

Refining capacity was increased about 80,000 b/d in 1956. Additional facilities were built by Nippon Oil Refining at its Muroran plant, by Kita Nihon Oil Company at Hakodate, by Toa Nenryo Company at Wakaya, etc. Daiko Oil Company is adding a 3000 b/d Houdriformer at Yokkaichi. Idemitsu Kosan at Tokuyama and Showa Oil Company at Yokkaichi were constructing new plants at the end of 1956. The Showa (Royal Dutch-Shell 75 percent and Mitsubishi 25 percent) plant will have 40,000 b/d capacity and will cost $39,000,000.

Idemitsu Kosan's 30,000 b/d plant will cost $25,000,000.

Japan Petroleum Exploration Company, established in December, 1955, explored Hokkaido, Northwestern Honshu and Kanto Plain, and found oil production at Biratori SK 2 (Hokkaido) and good oil indication at Tamugiyama SK 1 (Niigata). The company completed 17 exploratory wells in 1956. The Teikoku Oil Company found two gas fields in Niigata Pref. and deeper pools in Niigata gas field. A new heavy U. S. rig permitted 12,000-ft tests and also this year Japan will have some offshore drilling near the west coast of Honshu.

More than 94 percent of domestic crude was produced by the Teikoku Oil.

JORDAN

Plans are reported for a 5000 b/d refinery at Ez-Zirka near Amman financed by Jordan government and private citizens.

Trans-Arabian Pipeline Company has entered negotiations to increase payments to Jordan and other countries for its transmission line. Trans-Arabian was the sole line to keep in operation during the Suez crisis.

Edwin W. Pauley has the only oil exploration concession.

KENYA

Geophysical work and shallow drilling has been continued in 1956 by BP Exploration Company in the southeast part.

An application for an oil exploration license was made by Frobisher, Ltd., covering 7900 square miles.

A geological survey is being made.

KOREA

A 1300 b/d urea plant is being constructed at Chung-Ju by the Korean government.

KUWAIT

Prod. 1,092,553 b/d R. C. 30,000 b/d

Exploration drilling in North Kuwait continued throughout the year and two wells were drilled to final depth and cased but not perforated. No production facilities are available in the area yet and the wells will be completed at a later date. Drilling continues on a third exploration well in the same area.

Four drilling rigs were in operation during the first half of the year and five during the second half.

Production facilities were increased by the commissioning, in July, of a gathering center (No. 11) in the Burgan field with a capacity of 180,000 b/d.

At the loading terminal at Mina al-Ahmadi No. 9 loading line (30-in. diameter) on the jetty was put into operation in December.

Crude oil exports averaged 1,067,746 b/d. They were severely curtailed in November by the Suez crisis but started to improve in December as a regular supply of tankers began to arrive via the Cape route.

Work on the expansion of the refinery at Mina al-Ahmadi, 17,000 b/d capacity is making good progress and present indications are that, despite interruption to shipping, completion will not fall far behind the target date of the end of 1957.

The refinery averaged 28,804 b/d in 1956 and bitumen plant processed 238 b/d.

KUWAIT-SAUDI ARABIA NEUTRAL ZONE

Prod. 32,034 b/d

American Independent Oil Company and Getty Oil Company (formerly Pacific Western Oil Corporation) completed 28 wells in the Wafra field, Kuwait-Saudi Arabia Neutral Zone. One exploratory well was drilled northeast of the Wafra field to a depth of 4529 ft, but was dry and abandoned.

At the end of 1956 there were 60 wells in the Wafra field. Of these, 14 were completed in a shallow (1200 ft) Eocene Zone by Getty Oil Company, while Aminoil completed 44 in the Burgan sand and two in the Ratawi oolitic limestone horizon discovered in 1954. The Eocene and Ratawi wells are now shut-in pending installation of additional facilities.

Total production for 1956 was 11,724,585 bbl. Of this 126,913 bbl were produced from the Ratawi, 260,156 bbl from the Eocene and 11,337,516 bbl from the Burgan. Total cumulative production to date is 26,560,032 bbl.

Facilities for handling and shipping crude oil in the Kuwait Neutral Zone have been increased, with Pacific Western building a gathering center and a pipeline to the marine terminal, Mina Saud.

LEBANON

R. C. 20,500 b/d

Iraq Petroleum Company's Tripoli refinery, which normally depends on oil piped through Syria, was kept in operation by using oil shipped from storage tanks at Banias, Syria, after the pipeline was damaged.

Only other refinery is at Sidon, the terminal of Tapline, Aramco's line from Saudi Arabian fields. This 9000-b/d plant is owned by Caltex and Socony.

LIBERIA

Texas Gulf Producing in association with W. R. Grace and Company plans exploration on a concession here. Cities Service relinquished its rights in Liberia.

LIBYA

Some 12 companies began survey work in 1956, on concessions granted in compliance with a new and reasonable petroleum law.

Libyan American Oil Company (an associate of Texas Gulf Producing Company) is drilling in Libya in north Cyrenaica.

MADAGASCAR

The Société des Pétroles de Madagascar (A P M) during 1956 had three seismic crews and one gravity meter crew in this island off the African east coast. Two drilling rigs, one heavy and one medium, were in operation.

MALAYA

Focal point for oil tankers in the Far East is on the Island of Pulo Bukom, not far from Singapore. Here Shell has one of the largest oil trans-shipment installations in the world with 65 storage tanks.

MALTA

BP Exploration Company has one test drilling at Zabbar No. 1, three miles from the capital city of Valetta. Two other tests are planned.

MEXICO

Prod. 253,000 b/d R. C. 440,000 b/d

In 1956 the Mexican government allowed Pemex $536 million for expenditures, about half to go to expansion and development of the state monopoly's facilities. Mexico's growing consumption has put a strain on operations, particularly on refining and transportation.

Although exports continue to grow, imports increase even more rapidly. Pemex must pay prevailing prices for imports and sell them at government controlled prices. Year before last Pemex was more than $21 million out of pocket on this account.

Nearly 450 wells were drilled in 1956 and production was increased more than 10,000 b/d.

Pipe lines played an important role during the year. FPC approved a gas line from northwest Mexico proposed by Texas Eastern. Pemex will sell 100 to 200 million cu ft a day to go into Texas Eastern's system near Provident City, Texas.

Pemex completed a 25,000 b/d products pipe line from Minatitlan refinery on the Gulf to Salina Cruz on the Pacific.

Additions to Pemex refineries to be completed in 1957 are: 300,000 Mcf/d natural gasoline plant in Mexico City; 16,000 b/d catalytic cracker at Ciudad Madero; 16,000 b/d catalytic cracker at Mexico City (where alkylation, polymerization and other units are also under construction for later completion); a 1000-b/d vacuum unit at Minatitlan, and a 12,000 b/d cracker at Salamanca.

MOROCCO

Prod. 1467 b/d R. C. 4000 b/d

Production continues to decline despite persistent exploration and development by the French government firm, Societe Cherifienne des Petroles.

A new sand was discovered in Rharb-Prerif basin.

Five rigs drilled 11 wildcats without success and 9 field wells of which 7 had oil, one was dry and one was an input well. Now 92 wells are producing in all the fields.

Only 1970 b/d throughput was averaged at the refinery at Petitjean.

MOZAMBIQUE

Mozambique Gulf Oil Company has one rig in this Portuguese Protectorate in East Africa. Drilling was resumed.

MUSCAT AND OMAN

Petroleum Development (Oman) Ltd. (IPC) is surveying the southwest coastal region. A test is being drilled at Jebel Fahud.

Libya was one country that profited by an operative petroleum law. A dozen companies were surveying their grants in this country. Here British Petroleum and the Libyan government sign a concessions agreement. Seated at the desk is H. E. Salam al Qadi, (Libyan Minister of National Economics,) while Ansi al Qassim (chairman of Petroleum Commission) stands beside him. Seated at left is D. R. Macpherson, second from right, K. R. Henshaw, both representatives of BP subsidiaries.

— Courtesy British Petroleum Company

NETHERLANDS

Prod. 21,290 b/d R. C. 261,000 b/d

Production shows some decline from 1955. Exploration is underway in the southwest by Nederlandse Aardolie Mij (Royal Dutch-Shell and Jersey Standard). Bataafsche Petroleum Mij. (R. D.-Shell) is making an underwater survey up to 30 miles offshore.

Both present refineries, which are at Pernis (Rotterdam), are being expanded. At Caltex plant a 7000 b/d Platformer and 4000 b/d desulfurization unit are under construction. At Royal Dutch-Shell's huge 220,000-b/d refinery a 12,700 catalytic reformer and a 24,200 catalytic hydrogenation unit will be completed soon.

Esso Nederland plans a refinery at Rotterdam also. Construction is scheduled to begin this year and completion in 1960. It will have about 40,000 b/d and cost nearly $30 million.

An interesting development in the Netherlands is the formation of Sappeur N. V. by most oil companies in France, Germany, and the Benelux countries. Chief objective of the firm is a pipeline system from Marseilles to Cologne and Rotterdam. Oil transport is needed inside Europe to meet growing demand.

NETHERLANDS ANTILLES

R. C. 650,000 b/d

Aruba. Lago (Jersey Standard) is building a 20,000 b/d Hydrofiner at its 440,000 b/d plant, go on stream this year.

Curacao. A catalytic cracker is being installed at Royal Dutch-Shell's 210,000 b/d plant. Refinery runs here were 297,500 b/d the first half of 1956. This includes crude intake to cracking plants.

NEW CALEDONIA (French)

The Société de Recherches et d'Exploitation de Petrole (SREP NC) in New Caledonia during 1956 had one geological crew and two marine geophysical crews in the field. This French island is east of Australia.

NEW GUINEA (Netherlands)

Prod. 7100 b/d

Netherlands New Guinea Petroleum Company (NNGPM) (Stanvac 40 percent, Shell 40 percent, Caltex 20 percent) received in 1956 an extension of its oil exploration concession covering the Western New Guinea concession. It was approved by the Netherlands States-General. A new local firm is reported to have applied for a concession on the Surinam coastal area.

Three geological field parties, three gravity meter parties and one seismic party were active in 1956 for NNGPM. Six new exploratory wells were spudded in and five wells were completed during the year. Four were dry holes. Three development and four wildcat wells were completed in the development program; all of the former were producers.

Highlight of the NNGPM operations was the drilling at Salawati Island of a wildcat supported entirely by helicopter.

Three small fields of NNGPM are producing.

NEW ZEALAND

Prod. 14 b/d **R. C. 80 b/d**

During the summer of 1956 BP concluded arrangements with Todd Brothers of New Zealand for joint exploration for oil on the east coast of the North Island. A similar arrangement, announced in 1955, exists with Todd Brothers and the Shell Group for exploration on the west coast of the North Island.

The small New Plymouth field is declining and drilling has not helped. The new agreements, however, are a prelude to more comprehensive exploration and extensive drilling.

Consumption runs about 25,000 b/d. Per capita consumption of 154 gallons a year is among the world's highest.

NICARAGUA

Waterford Oil Company of New Orleans obtained the country's only concession, formerly that of Miguel d'Escoto. The government permitted the company to exchange its rights on the Pacific side for the coast land and continental shelf of the Atlantic. Drilling is planned for early 1957.

NIGERIA (British)

At last the heavy investment in this West Africa territory gives some promise of paying off. Oil was discovered in East Nigeria at Oloibiri and at Afam, 20 miles east of Port Harcourt by Shell-BP Development Company of Nigeria. Confirmation wells are now drilling.

Shell and BP spent 18 years and $40 million to get this far. To put in production facilities, pipelines and tanker loading facilities will cost more than $14 millions so economic production estimates must be gaged for further expenditures.

Socony Mobil has an exploration concession in North Nigeria covering 180 million acres and is conducting reconnaissance.

NORWAY

R. C. 2000 b/d

Esso announced plans for construction of a $30-million oil refinery and loading facilities in Norway. The plant will process 40,000 bbl of Mideast oil a day. Construction will begin around 1958 on the Oslo Fjord.

Esso has the present plant at Valloy.

PAKISTAN

Prod. 5777 b/d **R. C. 5400 b/d**

East Pakistan. 1956 recorded the discovery by Pakistan Petroleum, Ltd. (70 percent Burma Oil, 30 percent Pakistan government) of East Pakistan's first gas field at Sylhet. First and so far the only indigenous source of fuel, this will play an important role in the economy.

With the proof of large gas reserves in Sylhet consideration is now being given to projects for the use of the gas; these include a 145-mile gas-line from Sylhet to Dacca.

PPL completed seven party months of reflection seismic work.

West Pakistan. During the year three new wells commenced drilling in West Pakistan at Karachi, Khairpur and Adhi. At the end of the year both Karachi and Khairpur wells were drilling below 8000 ft. On completion the Khairpur well will be thoroughly tested; there have already been indications of gas. Karachi test had a few gas shows and this well will also be tested after drilling is over.

PPL's natural gas field at Sui supplied more than 20 million cubic feet of gas per day to industrial consumers in Karachi, Khairpur, Hyderbabad and Rohri during 1956.

Production from the Khaur, Dhulian, Balkassar and Joya Mair oil fields in the Punjab totaled 2,114,395 bbl.

Standard-Vacuum spudded in its first well on the Indian sub-continent in West Pakistan on May 21, 1956. It was abandoned as a dry hole and the rig moved some 200 miles north where, on December 29, another well was begun. During 1956, field parties carried out a 14-party months on geological survey; 22-party months of gravimetric work; and 29 months on seismic surveys.

PPL did nine party months of reflection seismic work and four party months of gravity meter survey.

Hunt International Petroleum has abandoned its first well on the Mekran coast at Dhak, 80 miles west of Karachi, at 8400 ft and is drilling a second well two miles north, where there is a fishing job at 14,622 ft.

PANAMA

Concessions are held in this Central American country by Union Oil Company of California, in the Bocas de Toro province; and by Consolidated American Industries on the Caribbean Coastal area of the Darien Isthmus.

Union is drilling at Yorkin No. 1, just across the border from its Costa Rica discovery well. Consolidated has a test drilling near San Blas.

The government signed contracts with two Panamaniam companies — Panama Refinery and Petrochemical Company and Panama Refining Company — to build plants. The latter has bought a site on Las Minas Bay.

PAPUA (New Guinea)

British, Australian, and American interests continue the expensive search for oil in the steaming jungles of Australian-owned Papua. Most active are Australasian Petroleum and Island Exploration companies. Both are owned by BP, Stanvac and Oil Search (Australian firm).

Field parties carried out 17-party months on geological surveys; 24-party months on seismic surveys; and 12-party months on gravity meter work. Four wildcat wells were active.

Kuru No. 1, which was spudded in on January 1, encountered gas at 998 ft and blew out. After a relief well was drilled, the gas was brought under control during May and the well plugged. Another wildcat was spudded on August 11 at Barikewa, four miles southwest of the middle reaches of the Kikori River. Another site for a deep test well was chosen in southwest Papua, close to the Morehead River and about 30 miles inland.

PERU

Prod. 52,192 b/d **R. C. 47,200 b/d**

International Petroleum (Jersey Standard) plans to buy a half interest in a 138,000-acre concession from Lobitos Oilfield, Ltd. Intercol expects to spend $40 million on development by end of 1961. The concession is on the northwest Peruvian Coast, adjacent to Intercol's Labrea-Parinas fields, the largest producers.

Drilling in the Sechura desert, south of this area, has been disappointing. Recently Intercol relinquished 700,000 acres in the desert, saying it drilled 9 dry holes.

Interest now centers on exploration east of the Andes. Compania de Petroleo Ganso Azul (76 percent Texas Gulf Producing) found the Ganzo Azul field which had been limited to local market until a 45-mile, 4-in., pipeline was laid to Pucallpa. Production now runs 3000 b/d.

Richmond Oil Company (Standard of California) conducted field geological work along the eastern slope of the Andes and on concession lands in the Oriente. Most of the acreage held in the Sechura Desert area in the north coastal region was surrendered.

A German-Peruvian joint interest group engaged upon exploratory drilling east of the Andes in Peru, has started upon the exploration of a new structure. The drilling rig was moved from the Cashiboya structure, where it had been operating before, to the Inuya structure.

Texas Petroleum Company drilled one 9800-ft dry hole on the bank of the Maranon River and is drilling a second wildcat.

Compania Peruana de Petroleo drilled four dry holes in the Ucayali River Valley and has begun a fifth test.

Largest refinery is Intercol's 44,000 b/d plant at Talara.

Peru's petroleum laws are designed to encourage both domestic and foreign capital and the government has maintained respect for private property. Consequently, every effort is being extended to find resources in a climate favorable to economic enterprise.

Consumption of oil products is rising steadily, amounting to about 36,000 b/d.

PHILIPPINES

R.C. 13,000 b/d

This year was marked with the most extensive oil exploration so far conducted by private concerns in the Philippines. Geological and aeromagnetic surveys covered approximately 6,500,000 acres in different islands of the Archipelago. A number of geology and geophysical crews were busy.

The government, through the Bureau of Mines, continued its reconnaissance exploration survey and covered southwestern Mindoro. Its paleontological laboratory services were made available to concessionaires and other private enterprises.

Philippine Oil Development started its Well No. 1 on the Tumauini structure in the Cagayan Valley in January and reached a record depth of 10,414 ft through Tertiary sediments in September, the deepest so far drilled in the Philippines. This was abandoned and a new site chosen on the same structure.

Standard Vacuum had two geological and one gravimeter crews working in preparation for drilling a well in the Cagayan Valley, Northern Luzon.

The Caltex refinery in Batangas continued with a throughput of 13,000 b/d. All crude was imported and amounted to 6,257,886 bbl during the year. Shell and Standard Vacuum were still negotiating

with the government on their plans to set up their respective refineries.

POLAND

Prod. 3600 b/d (?) R. C. 10,000 b/d (?)

Oil production has been declining but natural gas output has risen to more than 4¼ million cu ft a day. Gas lines have been laid from Silesia to Lodz to Warsaw.

Russian turbo drills and other equipment are used by the government industry. The 1956-60 plan calls for 60 percent increase in drilling.

Refinery runs were about 11,600 b/d more than stated capacity of the plants at Trzebinka and Rzeszou.

Consumption is estimated at 27,500 b/d. Recent reports tell of gasoline rationing because of the drop in oil deliveries from Rumania via Hungary.

PORTUGAL

R. C. 25,000 b/d

Mobil Exploration Portugal (Socony Mobil) drilled 2 dry holes and is drilling a third test south of Tagus River. Operations are conducted by Mobil in an arrangement with Companhia dos Petroleos de Portugal, owned by the government and Axel Johnson interests of Sweden.

SACOR'S plant at Cabo Ruivo has not run to capacity so far. It has throughput of about 16,800 b/d which equals consumption.

PUERTO RICO

R. C. 32,000 b/d

A 22,000 b/d refinery has been constructed by Commonwealth Oil Refining Company at Ponce on the South Coast. The company plans to double in capacity.

Caribbean Refining (Gulf Oil and others) has the only other refinery.

QATAR

Prod. 116,000 b/d R. C. 600 b/d

Ten new wells were drilled at Dukhan oilfield by Qatar Petroleum (IPC). This is the only field in the Qatar peninsula.

Shell Oil (Qatar) lost its $1½ million drilling rig in the Persian Gulf and has suspended its expensive exploration program offshore.

ROMANIA

Prod. 220,000 b/d? R. C. 160,000 b/d?

Output of the two fields of Cobia and Valea Caselor opened up after the war apparently rank first in the Romanian production list. Both are in the extreme west of Ploesti, district of Dambovita.

If the Romanians succeeded in increasing their oil output to more than 11 million tons, this is due not only to the activities of Romanian experts but in part also to work of foreign companies. A new production district, which has contributed to the increase of output in Romania, was opened up near the town of Targul Jiu northeast of the Iron Gate, in the Province of Oltenia.

One well was drilled to 13,123 ft, said to be the deepest in the country.

Romania's gas production in Transylvania is estimated at about 40 million cu ft a day. Gas lines are being constructed to Moldavia, the Banat, and Transylvania.

New refining facilities have been built in Moldavia.

SAKHALIN

Prod. 10,000 b/d (?)

Like all Soviet oil operations, this production figure must be guesswork.

SARDINIA

The Government of Sardinia, which like Sicily enjoys semi-autonomous status, has now for the first time issued an oil exploration permit, to Societá per Azioni Idrocarburi Sardegna.

SAUDI ARABIA

Prod. 986,129 b/d R. C. 189,000 b/d

The Arabian American Oil Company in 1956 produced 360,923,384 bbl of crude oil, the highest in Aramco's history. It exceeded 1955 production by 2.5 percent.

Aramco set this new record despite the closing of the Suez Canal. Average production was more than one million barrels per day during the first 10 months but fell approximately one-third during November and December.

Ras Tanura refinery, on the Persian Gulf, processed an average throughput of 198,532 bbl per day, 2 percent less than during the previous year. A $6,000,000 catalytic desulfurization unit was under construction. Designed to process 15,000 b/d of diesel oil, it was scheduled for completion in 1957.

Two-thirds of Aramco's production during the year came from the 140-mile-long Ghawar Field. Ghawar's cumulative production passed one billion barrels on December 25, 1956. The 20 deep wells completed during the year included 11 oil wells in the Ghawar field. In November the eighth gas-oil separator plant in this field was placed on stream. A new permanent community was constructed at 'Udhailiyah, near the center of the Ghawar field, to serve as a permanent base.

In Abqaiq field, where the cumulative production already had passed one billion barrels, the company's gas-injection plant in 1956 returned an average of 146,300 Mcf/d of gas to the producing formation. To supplement this pressure-maintenance project, Aramco began injecting water into the Abqaiq field on February 7, 1956. The water-injection rate reached an average of 40,000 bbl per day by the end of the year.

Aramco announced a maior oil discovery at Khursaniyah, 84 miles northwest of Dhahran, on June 22. The well was drilled to a total depth of 7612 ft. Potential production was developed in the A, B, C and D members of the Arab zone and in the Middle Jubailah zone. Completed in the Arab-D zone, the well had 32 API gravity oil.

At the end of the year, five rigs were drilling new wells — in the Dammam, Khursaniyah, Safaniya and Abqaiq fields and in the 'Ain Dar area of the Ghawar field. As of December 31, 1956, 164 wells were producers.

Eight exploration parties operated in the concession area: four seismic parties, three structure-drill parties and one gravity-magnetic party.

A 142-mile, 22-in. pipeline from offshore Safaniya field to Ras Tanura, and related facilities were 50 percent complete at the end of 1956. They were designed to permit production of up to 50,000 b/d from the Safaniya field by the spring of 1957. Additional facilities will permit the production of up to 125,000 b/d later this year. Cost of the new Safaniya facilities is estimated at $21 million. Crude oil from the Safaniya field, beneath the waters of the Persian Gulf, is heavier than other Aramco crudes and will help meet demand for fuel oil.

The Trans-Arabian Pipe Line Company delivered from Sidon, Lebanon, 121,052,745 bbl of crude oil during 1956. These deliveries, consisting of crude oil produced by Aramco in Saudi Arabia, averaged 330,745 bbl per day, highest in Tapline's history.

In order to expand its maximum throughput, Tapline is installing auxiliary pumping units and other facilities. The new facilities will make possible an average throughput of about 435,000 b/d during the calendar year 1958.

SICILY

Prod. 9500 b/d R. C. 55,000 b/d

About 25 companies search for oil in Sicily under satisfactory terms. Sicily is semi-autonomous and has its own oil laws. About 55 percent of the island is covered by exploration concessions and such companies as Gulf, Mediterranean Oil (Gulf 65 percent—MacMillan 35 percent), ARPE (Esso 51 per cent—Rasiom 49 percent), BP, Montecatini and a number of other Italian firms.

Production from Gulf's field near Ragusa, begun early in 1955, recently increased when a 45-mile, 14-in. pipeline was laid to Rasiom refinery at Augusta.

A seismic survey in southeast Sicily was carried out by BP during the summer to find a site for a second test well. BP's first test well, near Vittoria, found only a crude oil of low quality.

AGIP Mineria (ENI) is carrying out exploration work in central and eastern Sicily on Snia Viscosa concessions.

Islom is building a 12,000 b/d refinery at Palermo, northern Sicily, mostly to process bunker oil. At the Rasiom plant a 7300 b/d powerformer is being installed.

SOMALIA (Italian Somaliland)

Sinclair Somal Corporation (Sinclair 1/2, Conoco 1/6, Amerada 1/6 and Ohio 1/6 each) completed 24 party months of seismic surveys, 24 party months of surface geological work and spudded the first deep test exploratory well (Gira No. 1) on June 18, 1956.

Minerara Somalia (ENI) began a test early last year on its 11,000 sq mile concession in North Somalia. This is an Italian territory on the African east coast.

SOMALILAND (British)

Toward the end of the year BP obtained a license to search for oil in British Somaliland over an area of nearly 6000 sq miles of coastal strip between Berbera and the northwestern border. Seismic surveys are to start immediately.

Standard Vacuum completed three party months of geological work, in addition to 10 party months of gravity and magnetometer work.

SPAIN

R. C. 110,000 b/d

Ceisna has continued geophysical work and drilling jointly with C. Deilmann, a German firm. The Zuniga No. 1 well was abandoned at 10,171 ft after cutting 12 gas levels but production was uneconomical. In the same area, near the French border, the Apodaca No. 1 was a dry hole. Drilling at Lano No. 1 also in the same formation has shows of oil and gas. Alda No. 1, near Zuniga No. 1 is drilling. Further southwest in Burgos province Trevino No. 1 is drilling.

Ciespa operates at present with three drilling rigs. Two seismic teams and a party of 10 geologists and paleontologists worked during 1956. Deilmann is associated in these exploration operations.

Valdebro (Spanish government enterprise INI and an American group represented by DeGolyer and MacNaughton) drilled four wells during 1956. All were dry. A new rig to go over 12,000 ft has arrived. Valdebro has two geophysical teams, one gravimetric team and 8 geologists working.

Campso is drilling at Cubillo. It had during several months a geological team on this field.

American Overseas had two geologists inspecting all Campsa concessions.

Adaro (INI and Italian-government ENI) drilled several wells 3000 ft deep in the Guadalquivir river area, finding several gas showings.

Petrolifera Iberica, S. A. has drilled several shallow wells (1500 ft) at Orduna.

Finally, in Catalonia a private enterprise has commenced two wells intended to reach 3000 ft depth.

Cepsa (a private company in Canary Islands) has put on stream in its Teneriffe refinery a new crude topping distillation unit with a nominal capacity of 35,000 b/d. Repesa (52 percent INI, 24 percent CEPSA and 24 percent Caltex) has near completion a new topping unit of 40,000 b/d capacity and a platformer of 11,000 b/d at Escombreas, Spain.

SWEDEN

R. C. 41,000 b/d

Drilling operations that began early in 1955 in southern Sweden (Scania) under the auspices of The Geological Survey of Sweden, were interrupted during 1956, to be resumed at a later date, not fixed.

No substantial changes have taken place during 1956 in the capacity of the Swedish oil refineries. Swedish consumption of petroleum products in 1956 increased by about 12 percent from the previous year, some 180,000 b/d.

SWITZERLAND

R. C. 1800 b/d

Schweizerische Erdol AG (75 percent Swiss—25 percent German) was formed in 1956 with an expectation of a concession over 3 to 6 cantons. An intra-cantonal oil law has been passed by three cantons.

Middleland Company (75 percent Swiss —25 percent French) has an exploration concession in a southwest canton.

National consumption runs more than 40,000 b/d.

SYRIA

J. W. Menhall, a U. S. citizen of Syrian origin, is reported to have struck oil in his first well at a depth of 8800 ft near Karatshuk in the northeastern part of Syria. Menhall will drill new wells on the basis of an agreement with the Syrian government. He acquired equipment from Syria Petroleum (IPC) which relinquished its concession in 1957 after 20 years and $16,800,000.

Syrian government granted a concession covering the search for oil in an area of approximately 5800 sq miles in the northeastern part of Syria to Societe des Petroles "Concordia," Damascus, associated with Deutsche Erdoel-AG. The German Prakla company will carry out seismic reflexion surveys.

Syria has approved a contract with a Czechoslovak firm to build a refinery.

TANGANYIKA

D'Arcy-Shell Development has the only concession in this East Africa territory. Two rigs are in use with no success to date.

TRIESTE

R. C. 32,600 b/d

Esso Italiana is installing a 1000 b/d Powerformer at its 6600 b/d refinery. Aquila's refinery has a 26,000 b/d crude capacity.

TRINIDAD

Prod. 79,000 b/d **R. C. 135,000 b/d**

Crude oil production for Trinidad during 1956 amounted to 28,928,800 bbl, establishing a fourth successive record. This is 16.2 percent increase over 1955.

Details of drilling and production are summarized as follows:

	1955	*1956*
Crude production	24,896,000	28,928,800
No. of rigs	27	27
Wells Compltd.	228	263
Producers	196	225
Success ratio	86%	86%
Footage drilled	987,567	1,110,745

Exploration yielded favorable results in only three cases. Dominion Oil suspended Freeport 1-A as a potential gas well; Trinidad Northern Areas completed two deviated wells from its Soldado marine platform; and Shell Trinidad successfully completed Innis 2-A in the Ortoire area. Apex (Trinidad) Oilfields completed two deep tests, both dry.

Antilles Petroleum (Trinidad) successfully extended Brighton field with a shore deviated well of 7468 ft, bottomed some 6500 ft offshore. Antilles also carried out marine drilling in shallow waters off Pointe Ligoure with the Southeastern Drilling Company barge during the year.

Total crude runs amounted during 1956 to 123,000 b/d.

Trinidad Oil Company, formerly known as Trinidad Leaseholds, Ltd., was purchased by The Texas Company during the year, while British Petroleum acquired a controlling interest in the Trinidad Petroleum Development Company, Ltd.

Shell Trinidad Ltd. was formerly known as The United British Oilfields of Trinidad, Ltd. The name was changed to identify the company more closely with the Royal Dutch-Shell Group.

TRUCIAL COAST

Between Oman and Qatar lies the Trucial Coast, where exploratory drilling still goes on.

Early in 1956 plans were made for a survey offshore Abu Dhabi, where Abu Dhabi Marine Areas (BP 3/5—Compagnie Francaise des Petroles 1/5) is searching for oil. The small island of Das, 60 miles from the mainland, has been chosen as a base camp, and a harbour, temporary air strip, offices, stores, workshops etc. are being built. More than 5000 tons of equipment have been unloaded on the island. A deep test well will be drilled about 20 miles from the island, with the use of a special barge, mounting a rig capable of drilling to a depth of 15,000 ft, which is being built and towed to the Persian Gulf.

On land Petroleum Concessions (IPC) has drilled four deep wells along the coast without success.

TUNISIA

Compagnie des Pétroles de Tunisie (Royal Dutch 65 percent—Serept 35 percent), abandoned its oil exploration in Tunisia. Since 1949 it has spent $15,500,000 and drilled 11 wells. State-owned Société de Recherches et d'Exploitation des Petroles en Tunisie (SEREPT) plans tests in Djeffara and South Tunisia.

TURKEY

Prod. 2700 b/d **R. C. 6250 b/d**

Exploration concessions have gone to some 20 companies. Tidewater, Seaboard, and Atlantic Refining are associated. Geological work was started during June 1956 by detail mapping of surface structures. Seismic work was initiated in August.

American Overseas Petroleum (Caltex) is drilling near Gaziantep, 80 miles northeast of Iskenderun. Gilland Oil Company is drilling 20 miles south of Iskenderun. The test will be directional-drilled under the Mediterranean to 5000 ft.

Istanbul Natural Gas Company (associate of Ralph M. Parsons Company) is drilling 90 miles west of Istanbul.

Dielmann AG was granted four concessions in the western district of Turkish Thrace, in continuation of its field of activity on the Greek side. Till the end of 1956 geologic, gravimetric and reflection seismic exploration was performed.

Among others with licenses are Bolsa Chica Oil Corporation, Royal Dutch Shell, Esso Standard, Socony-Mobil, Tidewater, Husky Oil. Most of the acreage taken has been in the area west of the Iraq fields and near Turkey's two productive fields.

U. S.-Turkey capital is reported ready to construct a $15 million oil refinery at Izmit, southwest of Istanbul.

UNION OF SOUTH AFRICA

R. C. 20,000 b/d

Standard-Vacuum refinery at Durban increased its crude throughput to 20,000 b/d. SASOL for the first time began operation of its oil-from-coal plant, which cost an estimated $112 million.

A 3-mile products pipe line from Durban to Witwatersrand has been proposed to aid in distribution to inland centers. Consumption runs above 52,000 b/d now.

TURKS ISLAND

A Standard of California subsidiary has oil exploration rights to approximately 2,900,000 acres in the vicinity of Turks and Caicos Islands.

U. S. S. R.

Prod. 1,500,000 b/d (?)
R. C. 1,500,000 b/d (?)

Last year the sixth Five-Year Plan went into effect and already there are signs that Minister of Oil Industry Yevseyenko's path is not running too smoothly. Criticism is directed about 50-50 to those in the industry and those who supply or transport equipment for the industry.

The Ural-Volga Basin, largest producing area, is expected to supply the largest portion of the 91 percent increase in the 5-Year Plan. Output is to rise from 820,000 b/d in 1955 to 1,880,000 b/d in 1960.

Production of natural gas in 1955 was 350,000 million cu ft. The Soviet goal in 1960 is 1,450,000 million cu ft.

The plan calls for 9000 miles of trunk oil lines and 5500 miles of gas transmission lines. Some 20 new refineries are planned and construction is reported underway on plants in Leningrad, Molotov, and Gorky.

Although Russia's production seems scarcely enough for its needs, exports run more than 100,000 b/d.

Deepest well in the Soviet is said to be completed for production in the Baku. Production depth is reported at 15,787 ft.

UGANDA

The Geological Survey of Uganda of this Central African country, released in December, 1956, a book "Oil in Uganda," by N. Harris, J. W. Pallister, and J. M. Brown, and published by the government. It can be purchased for Shs. 12/50 from the Government Printer, P. O. Box 33, Entebbe, Uganda. A British protectorate, no oil company is working in the country at present. BP's tests were disappointing.

UNITED KINGDOM

Prod. 1200 b/d **R. C. 590,000 b/d**

BP Exploration Company continued oil exploration in many parts of Britain, and the recently discovered Egmanton field—close to the established Nottinghamshire oilfields, is being developed. In October the first water-borne geophysical survey to

be carried out by BP in United Kingdom waters took place off the south coast near Swanage and Lulworth Cove.

Egmanton raised production to the highest point. In 1956 a total of 230 wells in five fields produced about 400,000 bbl.

The first half of the year consumption rose 8½ percent but rationing after the Suez closure brought down the total.

BP's Kent refinery is being expanded from 90,000 b/d to 140,000 b/d. The scheme is additional to a previously announced project for a 2600 b/d aviation gasoline plant, and a plant to be built by the South Eastern Gas Board for the production of town gas from oil products.

To provide facilities for its Llandarcy refinery, BP commissioned a new coastal tanker jetty in March, and in September plans were announced for the building—subject to British Parliamentary approval—of a new terminal at Milford Haven, Pembrokeshire, capable of accommodating very large tankers. The terminal would be connected with Llandarcy by means of a 60-mile long buried pipeline.

Berry Wiggins and Company is adding to its Manchester refinery a 250 t/d distillation unit and other facilities.

Esso Petroleum (Jersey Standard) is expanding its plant at Fawley, near Southhampton, to 210,000 b/d. It is already the largest oil refinery in the United Kingdom.

An atmospheric distillation unit, a Platformer, and gas-treating facilities are being installed by the Shell Group at Shell Haven, England. The Group is also adding ammonia and fertilizer units.

Regent Oil (Caltex and Trinidad Oil) has plans for a $70 million refinery with a capacity of 100,000 b/d. The site has not been named.

At Whitegate, Ireland, a $25 million refinery is planned. Esso, Shellmex, BP, and Caltex have combined to construct the 30,500 b/d plant. It is scheduled for completion in late 1959.

Under consideration by Esso Petroleum is a $56 million refinery in the Milford Haven dock area of West Wales.

UNITED STATES

Prod. 7,175,000 b/d R. C. 8,720,000 b/d

More than 58,000 wells were drilled in the U. S. in 1956 with about 13,000 wildcats.

The Bureau of Mines reported total demand 4.1 percent higher; domestic demand 3.5 percent higher and exports 16.6 percent greater. Daily average domestic demand was 8,757,000 b/d compared to 8,827,000 b/d in 1955. Average crude runs to stills in 1956 were 7,959,000 b/d. Imports were 936,500 b/d crude oil, and 493,700 b/d products. Exports were 352,000 b/d products and 77,850 b/d crude oil.

URUGUAY

R. C. 27,000 b/d

ANCAP, a state organization, owning one rig and employing the services of a U. S. contractor, drilled two new exploratory wells in different areas in the northwestern part of the country. The wells, which reached basement at 7369 ft, were abandoned as dry holes.

Only refinery is ANCAP plant at Montevideo.

VENEZUELA

Prod. 2,456,000 b/d R. C. 519,100 b/d

For the first time since 1945, the Venezuelan government granted new oil concessions. High production emphasized the need of greater reserves. Bids for grants in the Lake Maracaibo area ran from $863 to $2,600 an acre, higher than offshore leases in the Gulf of Mexico.

Six companies gained their first concessions in Venezuela: Signal, Sun, Superior, Venezuelan-American Independent Oil Producers Association and Star.

Venezuelan Atlantic Refining completed 29 net wells, principally in the Junta, Oritupano and Tacat areas in the State of Monagas, of which 16 were producers. Net crude oil production during the year averaged 12,659 b/d. The company participated in seismic and gravity meter programs and structure drill work in the Lake Maracaibo and eastern Venezuela areas.

Venezuelan Atlantic Transmission, which distributes natural gas from fields in Guarico to industrial and commercial consumers in Caracas and nearby areas, increased its sales to 53,000 Mcf/d during November, 1956—about 15 percent higher than November, 1955.

Venezuelan Pan American Petroleum became active in exploratory operations early last year. The firm opened an office in Caracas and is staffing it with exploration personnel. Ven Pan Am is operating two land seismic crews in eastern Venezuela, two surface crews in the northeast and one water seismic crew in the Gulf of Paria and the open waters off Delta Amacuro on the northeast coast.

Phillips Petroleum acquired from Pantepec Oil Company, C.A., late in 1956 Venezuelan concessions of approximately 32,776 acres producing more than 5500 b/d oil and some gas from 109 wells. The properties are in the Mulata and El Roble Fields of eastern Venezuela, and are close to other Phillips production and to Phillips gas-processing facilities. Production is being increased by reconditioning and opening up an additional 49 previously shut-in wells. In addition, Phillips acquired Pantepec's one-half interest in a natural gasoline and crude stabilization plant in the Mulata Field.

Capacity of Bella Vista field gas-injection facilities is being approximately tripled by Phillips, and inauguration of gas injection in the Mata Grande field to recover additional crude oil has been undertaken. Completion of expansion work at the San Roque natural gasoline plant more than doubled capacity for producing natural gas liquids.

Richmond Exploration completed about 70 new wells in its Boscan field. Production was increased from 50,000 b/d in November 1955 to 75,000 b/d in December, 1956. A 10,000 b/d asphalt plant was constructed at Bajo Grande on Lake Maracaibo, and the Boscan field-gathering systems was expanded by the addition of new pump stations and lines. One outpost exploratory well was completed, indicating an extension of the Urdaneta field in Lake Maracaibo onto Rexco's shore concessions. Geological and geophysical surveys were carried on in both eastern and western Venezuela.

Creole Petroleum's large projects under construction or ready to be gotten under way in this or the coming years include: (listed in order of project name, year scheduled to be completed, and cost in millions of dollars): Tia Juana Gas conservation plant No. 2, 1957, $30.9; Tia Juana Gas conservation plant No. 3, 1959, $29.6; gas collection system in Bolivar Coastal fields, 1959, $13.2; San Joaquin conservation plant (50 percent Creole) 1957, $1.8—total cost; liquid gas plant, 1958, $11.2; Lake terminal for supertankers, 1957, $22.1; Lagunillas pump station and modernizing of tank farm, 1957, $3.7; generating plant for Puntagorda electric power plant, 1957, $3.2; La Salina Central, 1957, $4.0; fourth refining unit at Amuay refinery, 1957, $7.2; Hydrofiner (for better quality distillates), 1958, $3.0; lube plant, 1958, $6.3; deepening port and enlarging loading docks at Amuay for supertankers, 1958, $8.6; four supertankers of 32,000 tons each, 1959/60, $28.3; 76 centimeter pipeline Temblador to Caripito 140 kilometers, 1959, $7.8.

Construction has begun on a 212-mile, 20-in. pipeline from the Silvestre fields (Socony and Sinclair) in Barinas State, Western Venezuela, to Puerto Cabello. Capacity of the line will be 110,000 b/d to be expanded later to 170,000 b/d.

Refining facilities are in construction by a number of companies. BP is installing gas cycling at Cardon and at Curacao.

Shell of Venezuela is adding a 33,000 b/d catalytic cracker, an 80,000 b/d distillation unit and a 1400 b/d alkylation unit at its Cardon plant.

Venezuelan Gulf has a new $5 million orthoflow unit under construction at Puerto La Cruz.

The Venezuelan government is building a $60 million plant at Moron.

YEMEN

During 1956 reconnaissance surveys have been made of the concession owned by the Yemen Development Corporation for oil and other minerals. No well has yet been drilled, but a considerable amount of surface geology has been accomplished. Geologists are still in the area, continuing their work.

The German firm of C. Deilman Bergbau GmbH, which had been working in Yemen, pulled out. There was some disagreement over the concession.

YUGOSLAVIA

Prod. 4300 b/d (?) R.C. 19,500 b/d (?)

George de Mohrenschildt and George Mitchell, Jr., Dallas, Texas, oil consultants, have been retained by the government to advise on methods and machinery in oil operations.

The Sisak refinery has been increased to 7500 b/d capacity with a new still and cracking unit. It uses all the local crude from Croatia. At the Rijeka refinery only imported oil is processed. These two refineries can now supply all Yugoslavia's needs. Runs are under capacity.

ZANZIBAR

In May 1956 a test well was started on Zanzibar, by BP-Shell Petroleum Development of Tanganyika, which has a concession over this British protectorate. It is off Tanganyika in the Indian Ocean.

TOTAL FOR WORLD

Average oil production for 1956 was **16,609,231 b/d.**

Refining capacity at the end of 1956 was **18,541,924 b/d.**

$100 BILLION INVESTMENT

Cost of petroleum operations over the world are exceedingly high. J. E. Slater, chief economist of Creole Petroleum, said in October, 1956 that "gross investment in oil property, plant and equipment in the Free World is well over $60 billion." Almost two-thirds of this is in the U. S.

The Chase Manhattan Bank gives these figures for 1955: United States, $40.4 billion and Free Foreign $22.9 billion for a $63.3 billion total.

Add the estimated $9 billion spent in 1956 and at least the same in 1957, capital for the world petroleum industry is getting close to a $100 billion investment. Including USSR and other communist countries, the total probably runs more than that.

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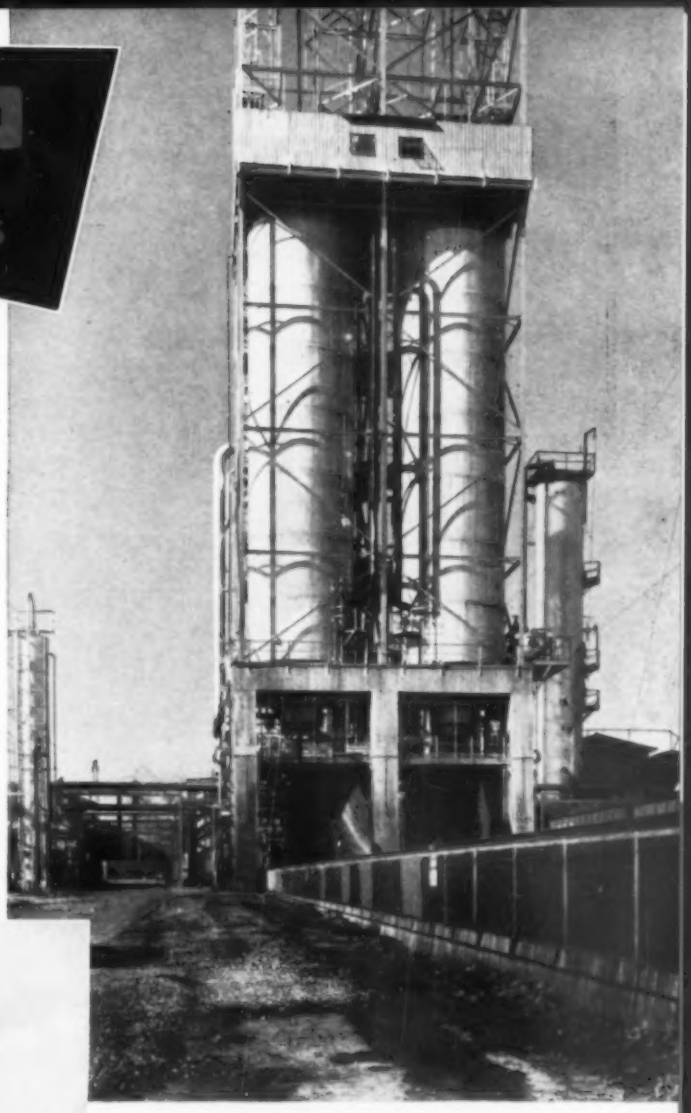

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◀ **MONEL HORTONCLAD and CHROME-NICKEL STAINLESS HORTONCLAD** were used in building this 15½-ft. by 142-ft. crude fractionator by CB&I. The top head and upper portion of the shell was Monel Hortonclad. Chrome-nickel stainless Hortonclad was used in the bottom head and lower portion of the shell.

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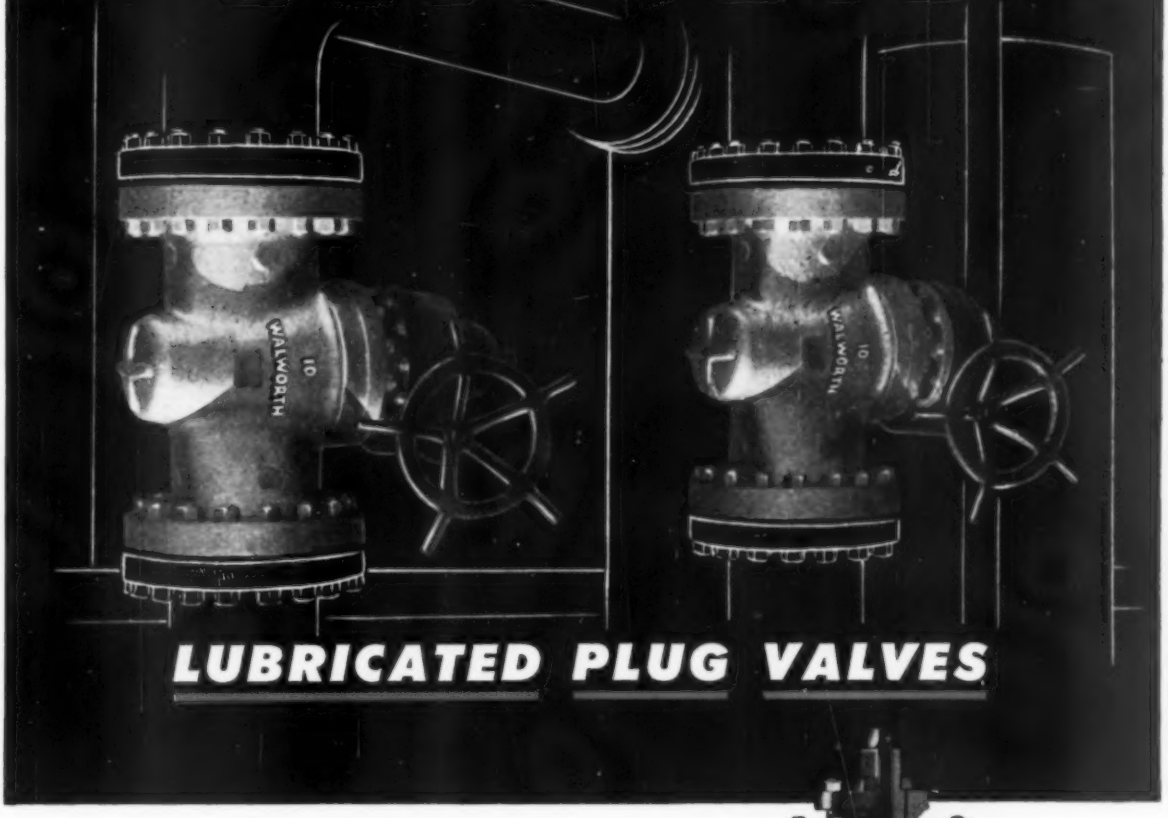
Rate of flow, bbl. per hr.	Pipe diameter, in.								Rate of flow, gal. per min.
	1½	2	2½	3	3½	4	5	6	
5	.62	.19							3.5
10	2.00	.53	.27						7
15	4.17	1.28	.55	.20	.10				10.5
20	6.82	2.01	.91	.32	.16				14
25	10.1	3.08	1.33	.48	.24	.13			17.5
30	14.0	4.21	1.81	.64	.32	.18			21
35	18.2	5.55	2.38	.85	.43	.24			24.5
40	23.4	7.04	2.99	1.07	.53	.30	.10		28
45	27.9	8.61	3.70	1.32	.66	.36	.13		31.5
50	34.7	10.5	4.45	1.58	.80	.44	.15		35
55	41.2	12.3	5.31	1.88	.94	.51	.17		38.5
60	48.3	14.3	6.21	2.20	1.10	.60	.20		42
65	56.1	16.6	7.15	2.51	1.26	.69	.23		45.5
70	64.5	19.2	8.17	2.85	1.43	.79	.27	.11	49
75	73.3	21.9	9.30	3.23	1.62	.89	.30	.12	52.5
80	82.7	24.6	10.5	3.66	1.83	1.00	.34	.14	56
85	92.5	27.5	11.7	4.11	2.05	1.12	.38	.16	59.5
90	102.7	30.6	13.0	4.56	2.28	1.25	.42	.17	63
95	113.3	33.7	14.3	4.99	2.50	1.36	.46	.18	66.5
100	124.3	37.0	15.8	5.43	2.72	1.47	.50	.20	70
125		55.7	23.8	8.33	4.10	2.26	.74	.31	87.5
150		78.6	33.0	11.6	5.80	3.14	1.03	.43	105
175		107.0	44.0	15.4	7.75	4.20	1.38	.57	122.5
200			57.5	19.8	9.94	5.38	1.77	.72	140
225			71.3	24.6	12.1	6.56	2.20	.90	157.5
250			86.2	30.3	14.7	7.95	2.67	1.10	175
275				35.9	17.7	9.52	3.23	1.31	192.5
300				41.9	20.7	11.2	3.73	1.53	210
325				48.2	23.8	13.2	4.29	1.80	227.5
350				55.9	27.6	15.0	4.98	2.05	245
375				65.5	31.0	16.8	5.66	2.30	262.5
400					35.3	19.1	6.44	2.60	280
425					39.0	21.2	7.13	2.93	297.5
450					43.7	23.7	7.99	3.25	315
475					48.7	25.9	8.72	3.62	332.5
500					53.3	28.7	9.66	3.98	350
525					58.8	31.6	10.4	4.34	367.5
550						34.3	11.4	4.76	385
575						37.5	12.4	5.10	402.5
600						40.8	13.3	5.44	420

[1]For used pipe add 25%. Additional allowance must be made for ells, tees, and other fittings.
[2]For brine, multiply by the specific gravity for a close approximation.

WALWORTH



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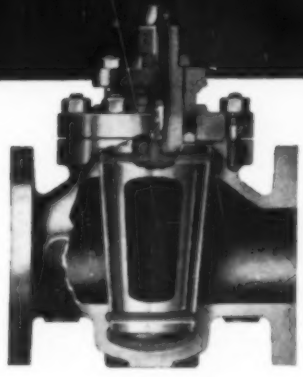

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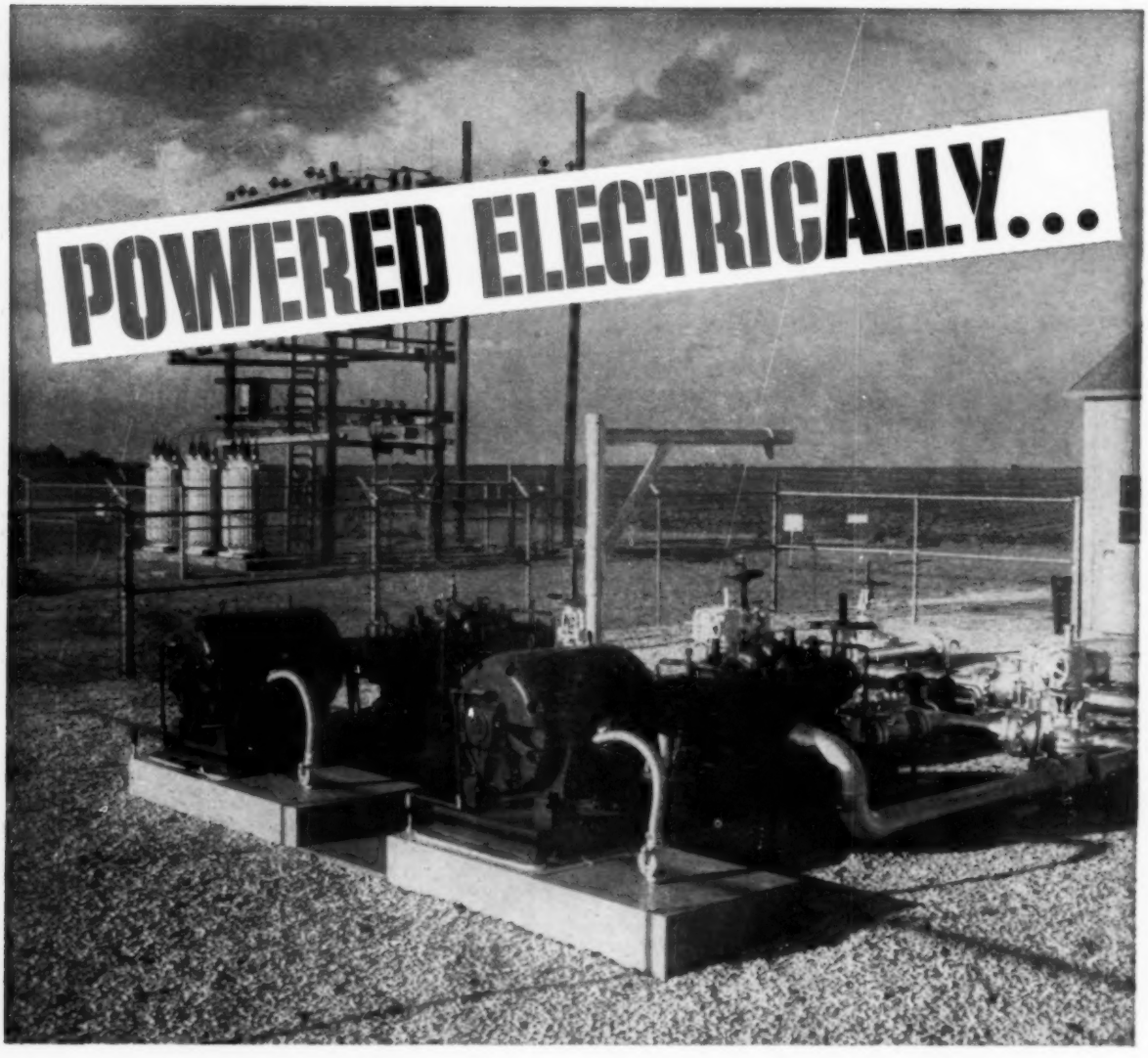

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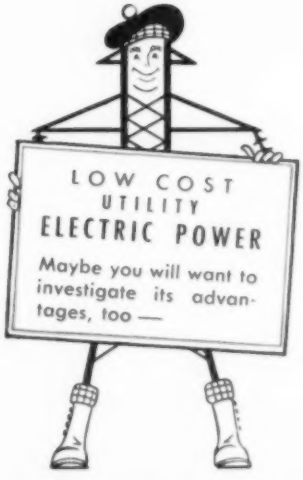

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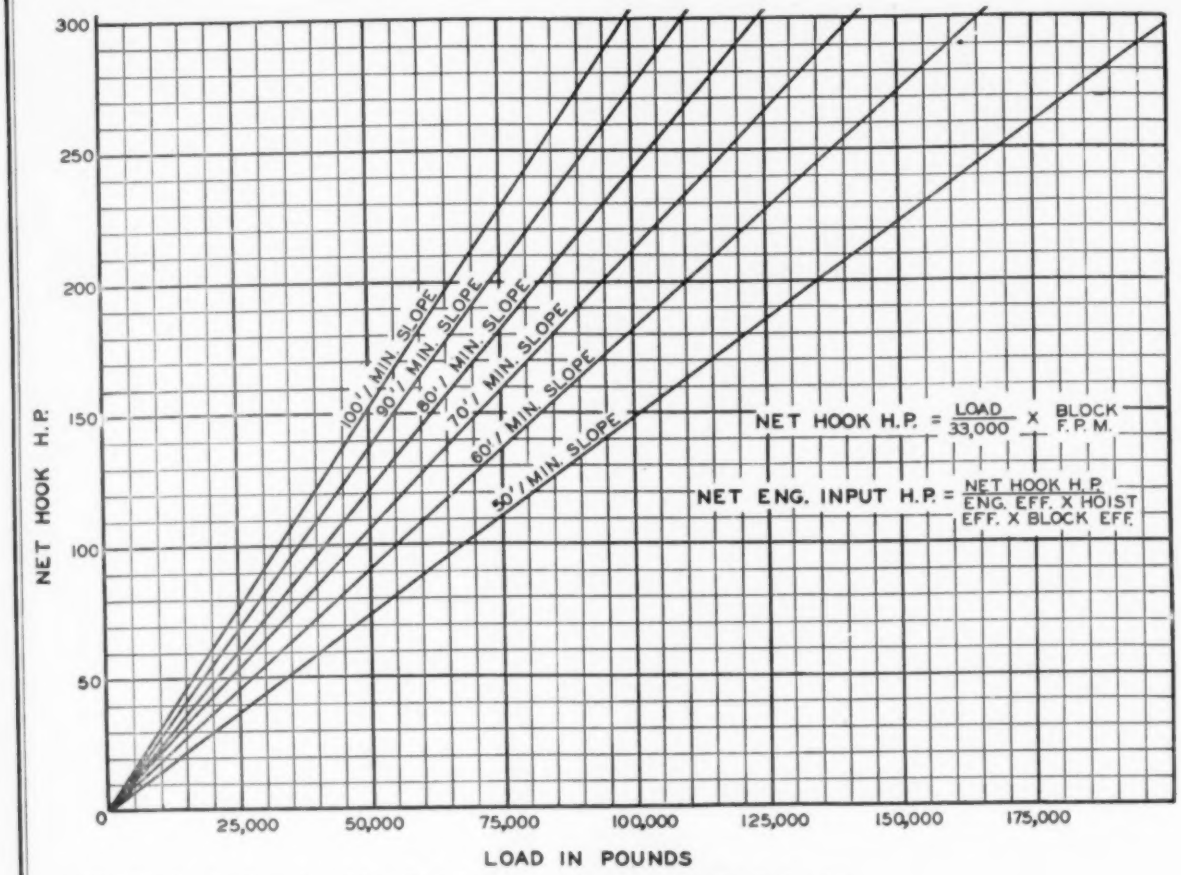


This chart is taken from the article entitled, "Selections of Internal-combustion Engines for Field Use," by James Moon, published in The Petroleum Engineer, September, 1946, page 57.

Example of use:

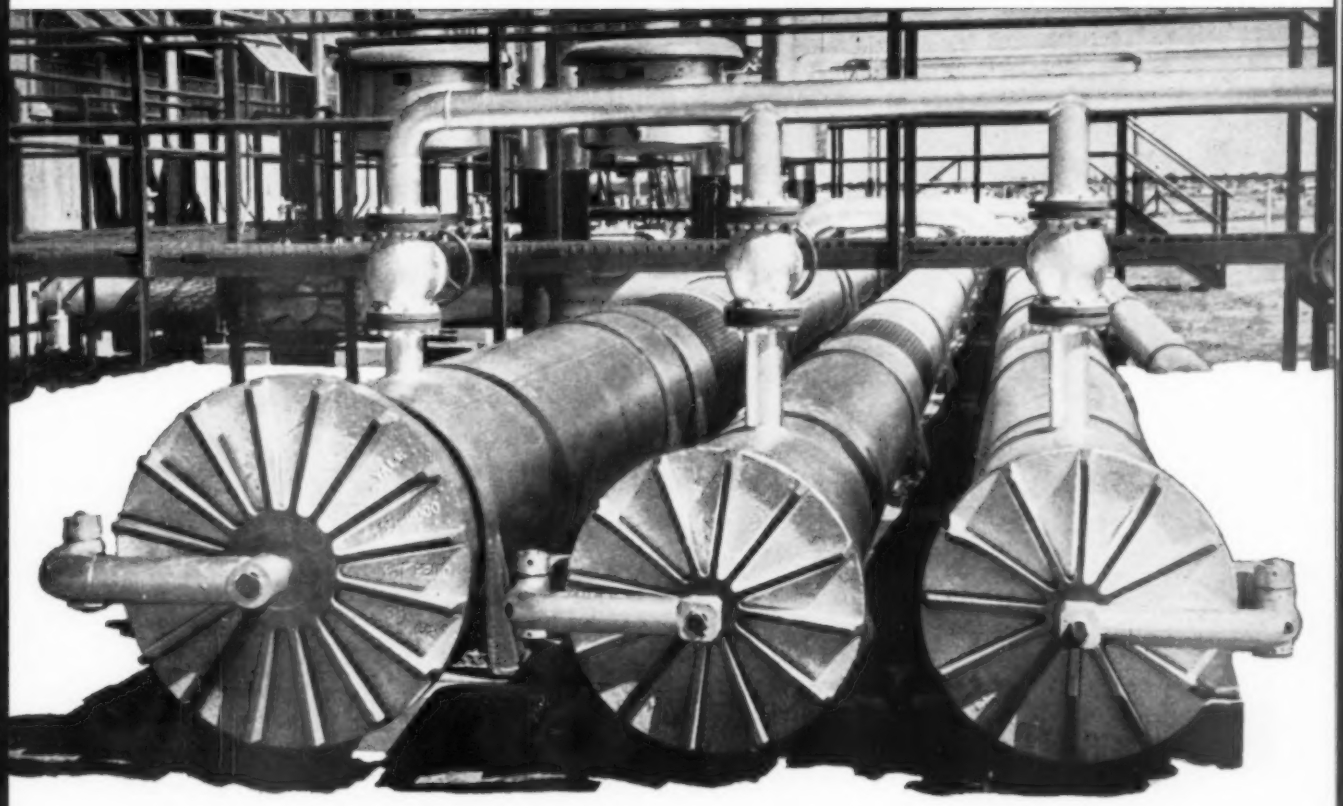
Given: A hook load of 81,000 lb. (10,000 ft. of 2½-in. tubing wet).

Required: The engine horsepower needed to hoist this load at the rate of 90 ft. per min. using a block with 4 lines.

Solution: Enter the chart from the 81,000 lb. load point on the lower scale. Follow upward to the diagonal line marked "90'/min. slope." Then, find the net hook hp. on the left-hand scale opposite the point of intersection = 221 hp.

Assuming the engine efficiency = 85 per cent; the hoist efficiency = 85 per cent; and the block efficiency = 96 per cent; then, the net engine hp required =

$$\frac{221}{.85 \times .85 \times .96} = 320 \text{ hp.}$$



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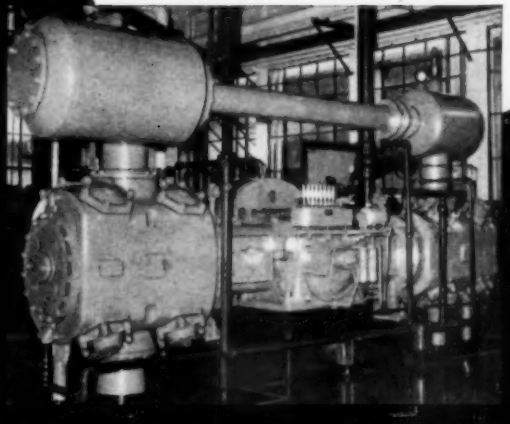

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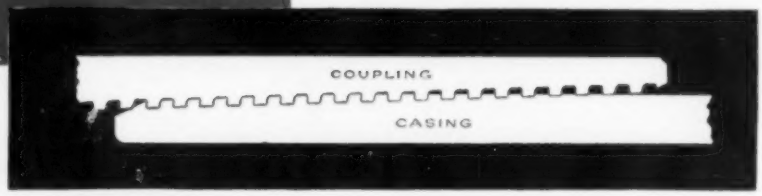

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Employee Attitudes and Productivity

Charles C. Gibbons

RECENTLY a large ship ran aground in a well-charted harbor. The man at the helm had brought ships into that harbor many times without difficulty. At the board of inquiry into the accident, the helmsman testified that he knew he was steering the ship aground.

When asked why he did not alter his course, he said that he was following orders from the captain. The helmsman was then asked why he did not ask the captain to alter the course of the ship.

"It wasn't my business to give orders to the captain and, besides, the captain was busy," was his reply.

Incidents similar to this one happen frequently in business and industry. Millions of men and women who work in factories are giving their jobs only part of what they have to give. They are going through the motions, they are getting by, but they are not as productive as they could be.

Business managers are often disappointed that workers do not seem willing to contribute more to their jobs. Workers, in turn, often find their jobs lacking in interest and basic satisfactions.

Business managers face the challenge of getting workers to participate fully in achieving the goals of their firms. Up to the present time, managers have failed to recognize fully the benefits of this greater participation.

Managers have failed to recognize that workers have hearts and heads, as well as hands, which they will gladly contribute to the business if they are encouraged to do so. If workers are to participate more fully, managers must adopt such participation as a conscious goal. Conditions must be set up which will encourage and facilitate participation.

Dr. Gibbons is industrial program director of The W. E. Upjohn Institute for Community Research, Kalamazoo, Michigan. His experience includes a period as director of personnel research at Owens-Illinois Glass Company. This is reprinted by permission from the November, 1953, issue of the *Michigan Business Review*, published by the School of Business Administration, University of Michigan.

Dynamics of the Relationship

Before managers can influence the worker to contribute more to his job, they must understand more fully the worker as an individual and the nature of the relationship between the worker and his company.

A man's behavior is directed toward the satisfaction of his biological needs such as hunger, thirst, and sex; and toward the satisfaction of his social needs such as security, recognition, and approval.

A worker will adopt the company's goals as his goals only if he feels that by so doing he can satisfy his own needs.

The basic human relationship in industry is the one between the worker and his supervisor. Before this relationship can be thoroughly sound, the worker must gain the insight that the "boss" is not the supervisor but that the real controlling factor is the need for achieving the goals of the organization.

In a manufacturing firm, for example, the real "boss" is the customer. When the worker understands this fact, he can accept orders from his supervisor without feeling subservient and without feeling that the supervisor alone is responsible for achieving the goals of the business.

If workers understand how their efforts contribute toward achieving the company's goals and, very directly, toward achieving their own goals, the whole relationship becomes more intelligent and satisfying. Workers who have this insight are motivated to contribute their full energies to their jobs.

Insight for the Worker

The problem might be restated then as: What can be done to help the worker achieve insight regarding his relationship to his supervisor and fellow workers?

First step is for the manager to recognize and accept the antagonisms and hostilities which the worker often feels toward his supervisor and his company.

It is not surprising that such feelings exist, for work is regarded by many workers as a burden to be endured in order that they can enjoy certain satisfactions away from the job. The work itself may have no appeal. It is quite normal for individuals to have both favorable and unfavorable feelings toward the same person or situation.

The manager should not be surprised, then, to find that workers have both favorable and unfavorable feelings toward their supervisors, toward their company, and toward the work which they are required to do. He can do much to help the situation by simply recognizing and accepting the unfavorable feelings which workers express.

Only when the working relationship is such that the worker feels free to express his feelings—favorable and unfavorable—can he gain insight into his relationship to his supervisor and to his fellow workers.

Second thing the manager must do is to keep workers informed.

Workers must know the goals of the organization, the major problems, and the plans which the managers and supervisors have for solving the problems. This process of explanation should start the first day the worker is on the payroll. There must be a thorough and well-planned program of orientation which will acquaint the new worker with the situation, with his supervisor and fellow workers, and with the relationship which his work has to the work of the entire organization.

Frequent interviews between the worker and his supervisor are perhaps the most effective means of keeping the worker informed. The manager should give information regarding the company's activities to the supervisors who, in turn, should pass the information on to the workers.

Although these interviews are basic.

other channels may also be used to keep workers informed. A company may hold meetings at which policies are discussed with workers. Bulletins and booklets may be distributed. The medium used to convey information to workers will depend upon the type of information and other circumstances.

The important thing is for management to recognize that one way of getting workers "on the team" and keeping them "on the team" is to keep them informed.

Wider Participation

Keeping workers informed constitutes just one half of the process of communications.

Also give the workers an opportunity to express their ideas regarding the operation of the company.

In the past, managers have done a better job of keeping workers informed than they have of getting and using workers' ideas. If managers wish workers to feel like a part of the company, they must solicit workers' ideas and they must use the good ones. By contributing their ideas to the operation of the business, workers not only help to solve problems but also, by participating, become identified with the goals of the organization in such a way that their motivation is increased.

The basic channel for the flow of such ideas should be through the supervisor. Every supervisor, at whatever level, should encourage the people under him to think independently about the processes and methods used on their jobs and about possible improvements.

The interviews between workers and their supervisors should permit a two-way flow of ideas. At the same time the supervisor is giving the worker information regarding the plans and needs of the organization, the worker should feel free to suggest any ideas that occur to him regarding the work to be done. There should never be any question as to whether the supervisor would welcome suggestions for improvement. One of the greatest challenges of this whole process is to change the attitudes of workers and supervisors and the spirit of their interviews so that such a two-way flow of ideas will occur. Even though this supervisory relation is basic, it is usually desirable to provide additional channels through which ideas may flow from workers to management. There are several special procedures which companies may use for this purpose.

Suggestion Systems

Many companies use a suggestion system as a means of stimulating and collecting workers' ideas for the improvement of the business. There is much to be said for such a system, for companies that use suggestion systems properly find that the number of constructive suggestions coming from workers is much greater than would otherwise be the case. It is easy to show that the ideas collected through a suggestion system save the company a great deal of money.

Perhaps even more important is the fact that workers who submit suggestions and see them put into effect get a real feeling of participation in the running of the business.

This feeling that they are part of the company may go far toward motivating them to do their best on their jobs.

Some companies use morale surveys as a means of finding out what workers are thinking. These surveys help to remove some of the guesswork from decisions affecting employee relations. Such surveys are most effective when they are limited to a specific topic of immediate interest to both management and workers.

When workers are allowed to express their opinions regarding matters that affect them, they feel more like a part of the company.

Communications Among Management Personnel

The process by which rank-and-file workers can participate in solving some of the problems of the company has been described. There is often a need, also, for better utilization of the ideas of supervisors and staff members. The basic channel for the flow of ideas is, of course, through the regular organization structure.

Special methods are often useful, however, in facilitating the flow of ideas. Some companies have daily meetings of men representing production, sales, engineering, and other phases of the business. These brief daily meetings make a great contribution toward coordinating the activities of supervisors and staff men and toward stimulating and utilizing the ideas of the entire group of employees.

Another way to get the ideas of supervisors and staff members is for a trained investigator to hold a private and confidential interview with each of them.

The purpose of these interviews is to stimulate these individuals to think critically and constructively about the company's operations and to collect their ideas for consideration by management. The ideas are then presented to management without identifying the persons who proposed the ideas. In companies where such interviews have been held, dozens of usable ideas have been suggested regarding operating efficiency, sales administration, product development, employee relations, and the organization and coordination of efforts. Supervisors and staff members, as well as rank-and-file workers, appreciate an opportunity to present their ideas to management.

Leadership in Process

It takes real leadership from managers and supervisors to get workers to feel and act like members of the team. Such leadership requires a thorough understanding of workers as human beings, and an understanding of the type of relationship that should exist among the members of the group.

Workers will be fully motivated only if they have insight into their relationships with supervisors and fellow workers. They must understand that, in working to achieve the company's goals, they will also be accomplishing their own goals.

Only if this identity of interests exists, and only if workers understand it, can there be a fully productive and satisfying working relationship.

Building such a relationship should be one of the major goals of every business manager.

Managers can help workers to understand their relationships within the company by making them feel free to express their feelings—both favorable and unfavorable—toward their jobs, their supervisors, and other factors in the work situation. Only after the worker has expressed his feelings can he proceed to deal with the more intellectual aspects of his relationship.

Managers can further help workers to understand their relationships within the organization by keeping them informed regarding the goals, problems, and plans of management. Interviews, meetings, and printed material provide workers with the facts they need for sound understanding.

Workers will feel that they are an integral part of the company only if they have an opportunity to express their ideas.

Managers should encourage workers to present their ideas to their supervisors, and to submit them through suggestion systems and attitude surveys. Ideas coming to managers through these channels should receive careful attention.

If a manager or supervisor is to be an effective leader of men, he must understand men — their needs, their motives, and, most of all, their feelings. He must also know how to facilitate the two-way flow of ideas between management and workers. Acquiring such knowledge, attitudes, and skills is an essential part of the development of a business manger. ★ ★ ★

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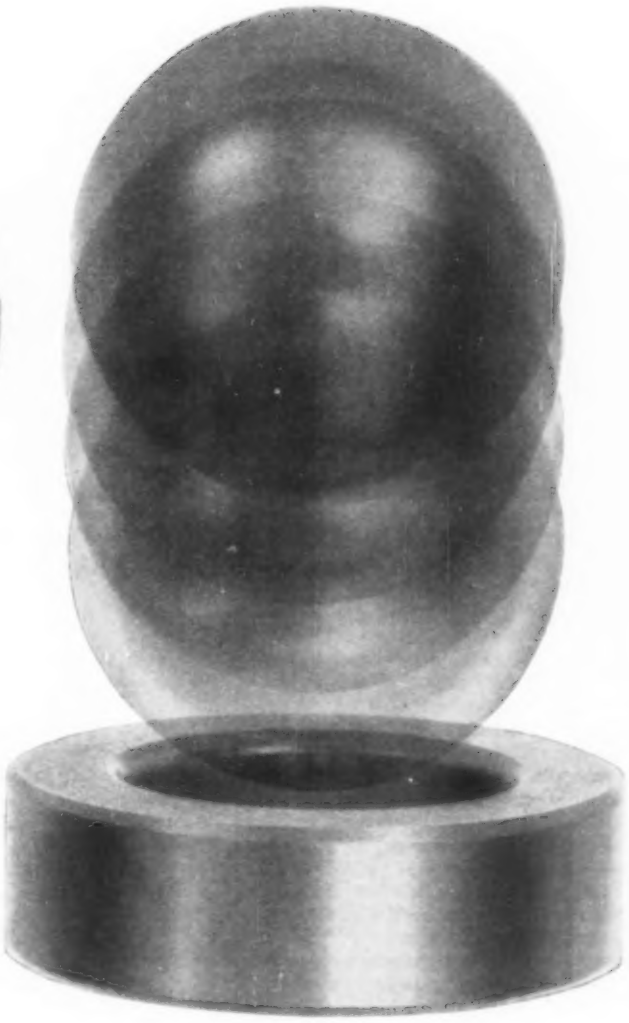

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Is Freedom Necessary to Science?

Freeman Dyson

Many U. S. scientists who demand virtually unrestricted freedom, at the same time insist that in Russia, where security measures are tighter than here, greater scientific progress is being made. The Baltimore Sun sought an answer and got one but the question remains . . . How much freedom is essential to a healthy scientific climate? This is a problem for industry as well as for government

I spent two weeks in May of this year going to scientific meetings in Moscow, talking with Russian physicists and sitting in Russian laboratories. A dozen Americans and many other foreigners were there. All of us reported, after we came home, that we were astonished at the enthusiasm, the competence, and the solid achievements of the Russian scientists.

Now, the editor of the *Sun* asks me a question. He says, "It is commonly stated by men of science that freedom is essential to a healthy scientific climate. And yet we learn from members of your group that Russian science, which has surely had to put up with security arrangements more stringent than ours, is in a flourishing condition, and that Russian scientists show evidence of the highest morale in their personal and scientific life. How can this be so?" He invites me to set down my thoughts about this question. And I am happy to do so, because the question is a real and important one. If science is to continue to flourish in our country, we scientists must succeed in making our needs understood by the public. For this reason, I welcome every chance to explain our situation, and especially to explain the nature of the challenge being offered to us by Russia.

Not Yet as Good

First of all, let it be clearly said that Russian physics is not yet as good as American physics. We were amazed at their work, not because it is so wonderful in itself, but because it has improved so much so fast. Some of our group had worked in Russian laboratories before the war. In those days almost every piece of equipment more complicated than a screwdriver was imported, mostly from Germany. Those gadgets which were made in Russia were not expected to function.

Today, all that has changed completely. The Russians know how to make scientific equipment, equal in quantity and quality to any in the world, and they have plenty of people who know how to use it. It is the speed and suddenness of their progress which are impressive. What they have done with their equipment is not yet so exciting. Since the war, six first-class and revolutionary experiments have been done in physics. Of these, one was done in Italy, one in England, four in the United States. None so far in Russia.

The second main fact which we established beyond doubt was this. Russian work in physics is now essentially free. I am not speaking here about political freedom. This, of course, does not exist in Russia, and will not exist in the foreseeable future. But a reasonable scientific freedom does now exist. That is to say, Russian physicists enjoy the basic professional freedoms, to work on problems of their own choosing, to publish their results, and to discuss their ideas with foreign colleagues.

These freedoms are restricted by security rules which are similar to ours, perhaps slightly stricter. In my own conversations, I found the only subject the Russians were unwilling to talk about was the construction of their latest electronic computers. This subject was clearly "classified" for them, although it is "unclassified" for us. On the other hand, they could talk about some experiments relating to thermonuclear reactions, which for us are still classified.

Freedom Is New

The freedom of Russian science is quite new. It came suddenly, soon after the death of Stalin. Until two years ago, nothing whatever was published of experimental work in nuclear physics. There was no possibility of personal contacts with foreign scientists, even from the satellite countries. And a high proportion of the physicists were engaged in military work. Two years ago, the whole atmosphere changed. People poured back from the military projects into pure science, publication was encouraged, and international meetings allowed.

All this had an intoxicating effect on Russian scientists. Suddenly to be given these freedoms, which they had not known for 15 years, filled them with optimism and self-confidence for the future. All the time we were in Russia, we could feel how happy they were to be allowed to talk to us. Their enthusiasm and high morale are directly caused by their new experience of freedom. The superstrict security system of Stalin's time produced high morale only in this negative way, like the man in the lunatic asylum who continually beat his head against a brick wall because it felt so good when he stopped.

The good experimental work which has been done in Russia was done after the new regime began. We found clear evidence that the different laboratories in Moscow had been isolated from each other during the earlier time, and that this had hampered their work considerably. For example, the big cyclotron in Moscow had been working since 1949, and was for several years a better machine than any working in this country. But nobody with imaginative ideas for new experiments had access to it, and so the basic experiments which established the properties of the meson were all done in America.

It is clear that the Soviet Government now understands the fact, which the American Government always knew, that scientific progress demands scientific freedom. It is also clear that

Dr. Dyson is a physicist at the Institute for Advanced Study, Princeton, New Jersey. This article is reprinted by permission from the *Sun*, Baltimore, June 26, 1956.

Research and Freedom

This editorial is reprinted from September 7, 1956 issue of Science, publication of American Association for the Advancement of Science. It discusses the question of whether full intellectual freedom is as important as we've been led to believe.

The *Sun*, Baltimore, had some pertinent remarks to make about the description a group of American physicists brought back from their visit to the U.S.S.R. this last spring. On 14 June the *Sun* remarked editorially:

"The reports of various members of this group on what they saw of Russian science are fascinating, and disconcerting. They are disconcerting for two reasons.

"First, they report that Russian science is flourishing, that the laboratories are beautifully equipped, that first quality personnel is abundant, that work of fundamental importance is being done, and that the Russians are not only bent on making Moscow the headquarters of the world so far as physics is concerned but may well succeed.

"That is disconcerting for obvious reasons. Still more disconcerting is the paradox which these reports expose. . . . In this country it is commonly stated by men of science and others that freedom is essential to a healthy scientific climate. The point has been made repeatedly in connection with criticisms of various government security arrangements. And yet we learn now from well qualified American physicists that Russian science, which has surely had to put up with security arrangements more stringent than the American, is in a flourishing condition and that members of the Russian scientific community show evidence of the highest morale in their personal and scientific life.

"How is this to be explained? Oddly enough, the reports of these American scientific visitors to Russia have included no explanation. Is the maximum of freedom important to the health of science, or isn't it? Have we been wrong in supposing that Russian science is less free than American science? These travelers lately returned from Moscow owe the public a clear answer."

The editor of the *Sun* followed this up by asking Freeman Dyson of the Institute of Advanced Studies at Princeton to prepare an article about working conditions of scientists in the U.S.S.R., an article that we reprint here. In the same issue of the *Sun* in which this appeared, the *Sun* had other editorial comments to make, from which we take the following excerpts:

"We welcome (Dyson's) article for several reasons. Not the least of these is the way he puts the Soviet achievements in science into perspective. Russian physics is good, he says, but not yet as good as American physics. And he attributes the Russian progress to the existence in the post-Stalin Russia of 'a reasonable scientific freedom. . . .'

"Yet Dr. Dyson goes on to say that security provisions in Russia 'are similar to ours, perhaps slightly stricter.' And he emphasizes that 'political freedom . . . does not exist in Russia.' Thus the paradox of scientific progress in an unfree society still wants an explanation.

"Men raised in the western tradition will hesitate to conclude that full intellectual freedom is perhaps a less urgent precondition of scientific progress than has been argued. On this point other scientists may wish to be heard. Surely the question is of compelling importance as the scientific race between free and totalitarian worlds gathers speed."

We agree that the questions the *Sun* raises editorially are of the first importance and we present them here for consideration by the scientific public.

the Soviet Government is spending enormous amounts of money on pure science, and seriously intends to make Moscow the scientific capital of the world. They have understood that the power of American science depends on America freely and openly attracting people and ideas from all over the world. And they intend now to beat us at our own game.

Public Support

I will end this discussion with one little story. After the meetings were over, a group of foreign scientists with two interpreters went sightseeing in the country around Leningrad. We walked by mistake into some kind of coast-guard station, evidently a restricted area, but nothing of importance. An ordinary Russian seaman came out to shoo us away, shouting, "*Nelzya*," which means "forbidden." At the same time, we noticed that our interpreters, evidently unwilling to be held responsible for this error, were walking rapidly away in the opposite direction.

So we stayed and had a friendly chat with the seaman in our broken Russian. When I said we were foreign scientists, he immediatley said, "Oh, I know who you are. You are the people who have been at the meeting in Moscow, and you know all about pi-mesons and mu-mesons." He pulled out of his pocket a crumpled copy of *Pravda* in which there was a report of our proceedings. He talked then with great warmth, saying, "Why do you not come to our country more often?" and, "Be sure to tell the people in your countries, and your wives and children, that we would like to see more of them."

I am fairly sure that this sailor had not been planted, briefed, or warned beforehand of our coming. If it had been a plant, the interpreters would not have walked away. And in Moscow, I talked with several other nonscientific Russians whom I met casually in the street, and they all made the same kind of response to me.

The moral of this story is that the ordinary Russian people have an understanding of the value and importance of pure science. And they understand and take pride in the fact that learned foreigners come to their country to exchange ideas. It is the atmosphere of public understanding which makes the prospects for the future of science in Russia look so bright. Their scientists have a professional freedom which is not much less than ours, and they have a public support which is in some ways much greater. I can only hope that an American coast guard sentry, confronted unexpectedly with a group of Russian physicists speaking broken English, would have behaved with equal intelligence and respect. ★ ★ ★

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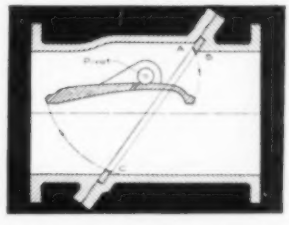

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Ed Kidd

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Members of the faculty of the Division of Business Administration, which sponsors the Executive Development Course, help maintain continuity of schedules and course offerings, preside over general sessions and develop plans for coming courses.

This emphasis on the use of outside talent is based on the idea that students of the course (who are themselves successful executives selected from a wide range of southwestern firms) will listen with an attitude of considerable respect to men who have already met and mastered complex operational and managerial problems of the area.

For example, the organization of an oil company was discussed and explained this year by R. M. Chan, first vice president of Magnolia Petroleum Company. Banking problems in the Southwest were handled by Dr. Watrous H. Irons, president of the Federal Reserve Bank of Dallas; financing expansion by E. O. Cartwright, partner of Merrill Lynch, Pierce, Fenner and Beane; organization of an industrial company by H. E. Perry, chairman of the board of Mosher Steel Company. Current capital requirements were discussed by W. A. Kirkland, chairman of the board of the First City Bank of Houston.

Each year national figures have lectured at special sessions of each Executive Development Course on the more general problems of our economy. Among these visiting lecturers have been Elliott V. Bell, editor and publisher of *Business Week*, Frank M. Porter, president of American Petroleum Institute; Ralph Delahaye Paine Jr., publisher of *Fortune;* Dillion Anderson, special assistant to President Eisenhower; William McChesney Martin, chairman of the board of governors, the Federal Reserve System.

At this year's Executive Development Course, Clifford F. Hood, president of United States Steel Corporation spoke on "Executive Responsibility in Today's Industry" and Jackson Martindell, president of the American Institute of Management, discussed "The Job of the Personnel Administrator."

To provide opportunity for free interchange of ideas between students and visiting faculty, sessions of the Executive Development Course are generally in an informal, business-conference pattern with time for question-and-answer sessions set aside for each major case study.

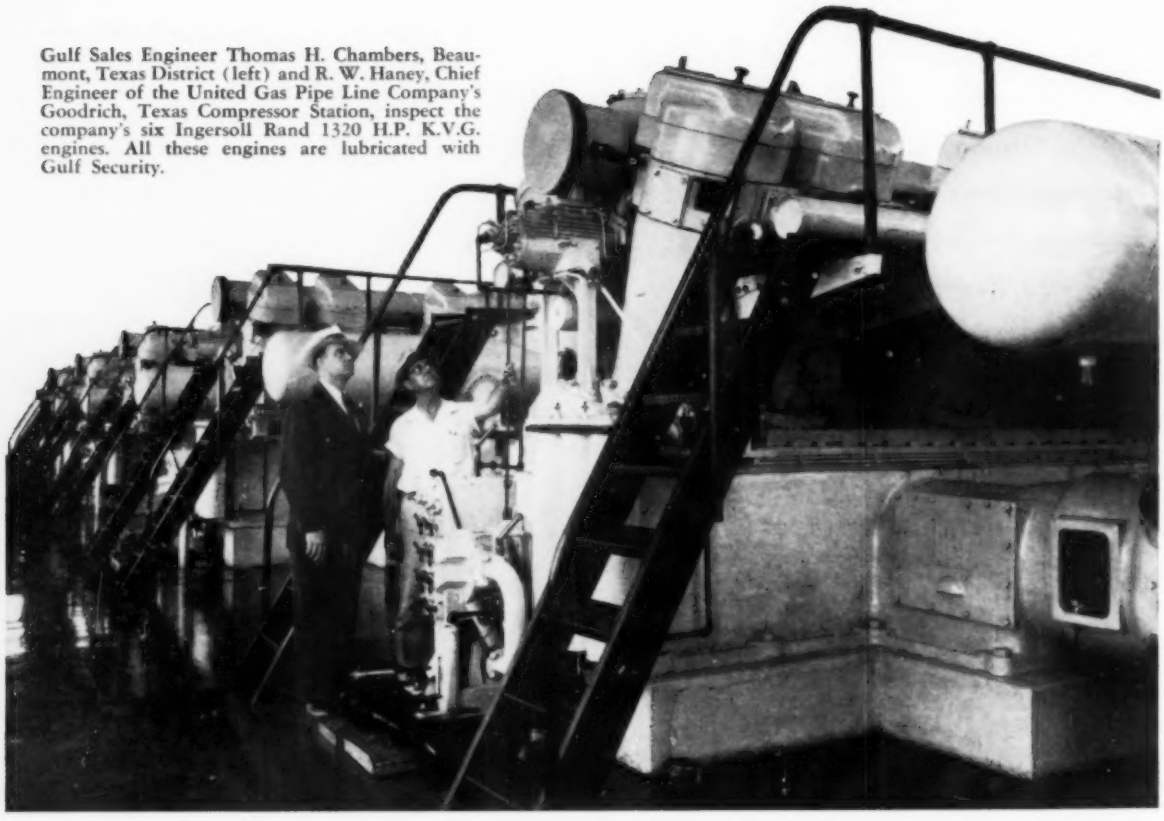
Panel sessions, using a number of men from one organization, who discuss problems arising on a departmental level and requiring solution at the organizational level, are scheduled each year. This year there was one consisting of Elliott A. Johnson, financial vice president and general counsel; Lee Y. Caldwell, supervisor of the trust department and James T. Cox, tax attorney, all of Schlumberger Well Surveying Corporation. These men discussed problems of fringe benefits.

The course is limited to approximately 35 executives nominated by their companies for the three-weeks training course, which is held generally in late January and early February. To be enrolled, they must be approved by the steering committee for the course.

Tuition for the course, covering enrollment fees and instructional materials, is $350.

Students are housed in the Memorial Student Center on the campus of Texas A&M College and all sessions are held there.

All registration applications or requests for information on the Executive Development Course should be sent to T. W. Leland, head, division of business administration, Texas A&M College, College Station, Texas. ★ ★ ★



Gulf Sales Engineer Thomas H. Chambers, Beaumont, Texas District (left) and R. W. Haney, Chief Engineer of the United Gas Pipe Line Company's Goodrich, Texas Compressor Station, inspect the company's six Ingersoll Rand 1320 H.P. K.V.G. engines. All these engines are lubricated with Gulf Security.

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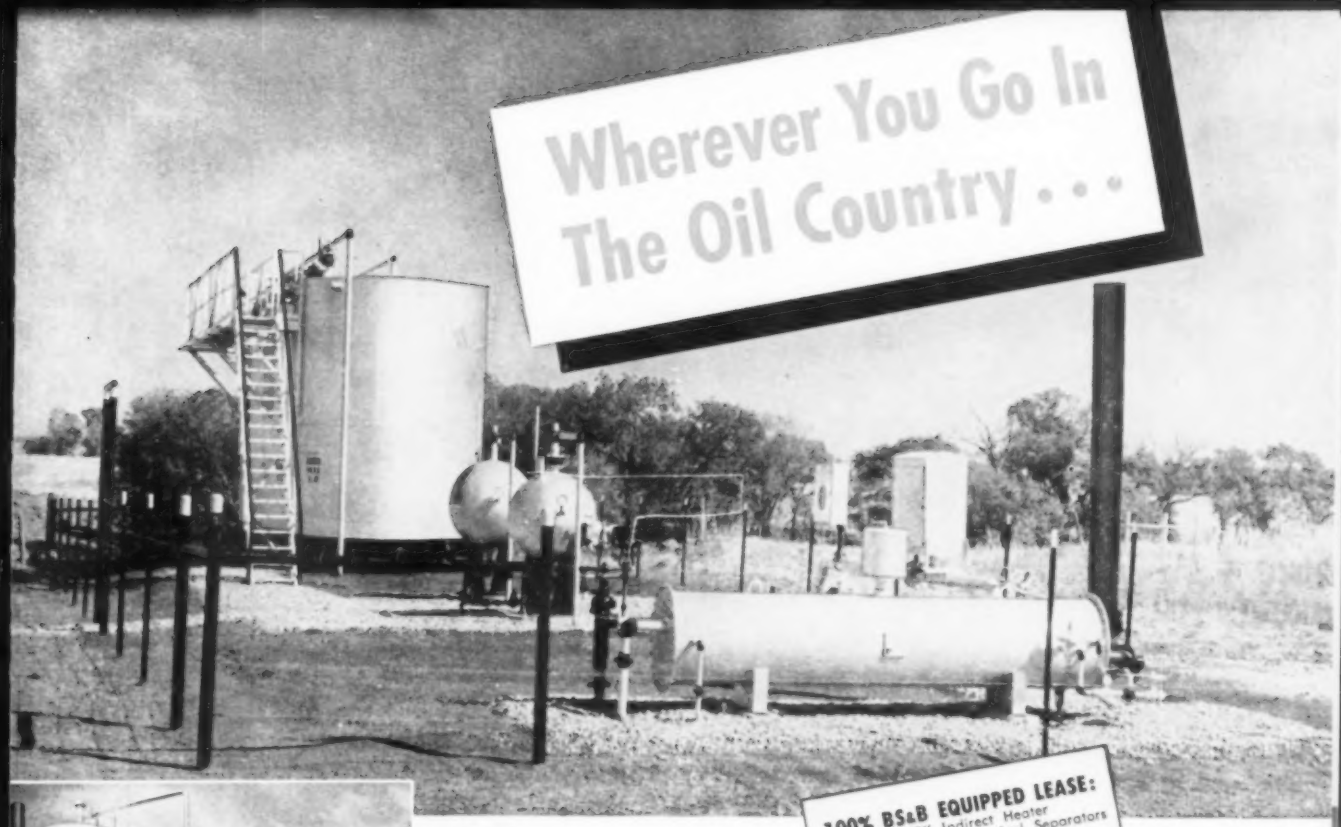

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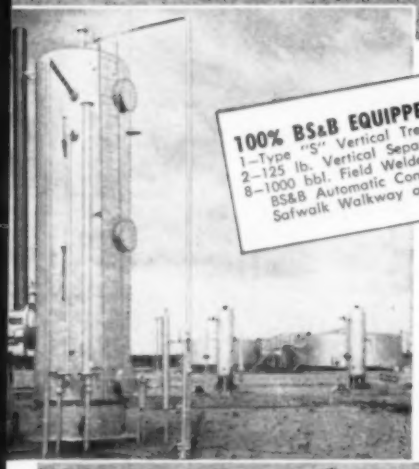

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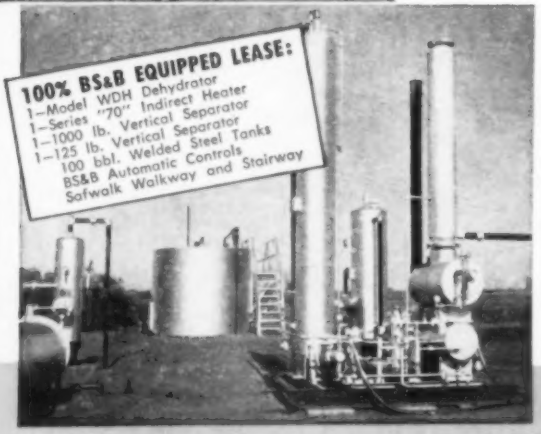

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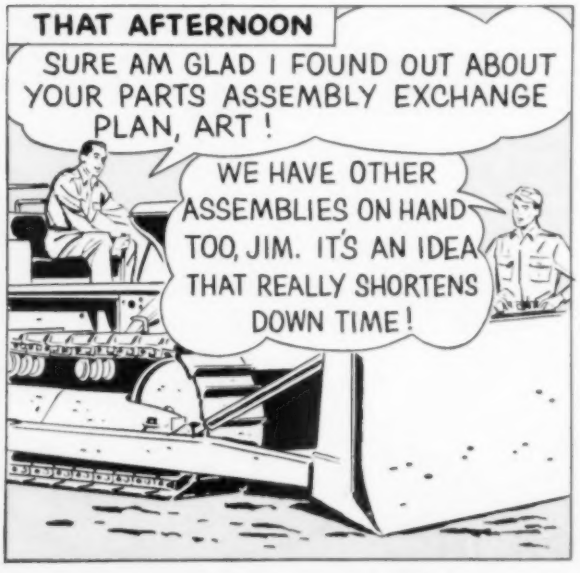
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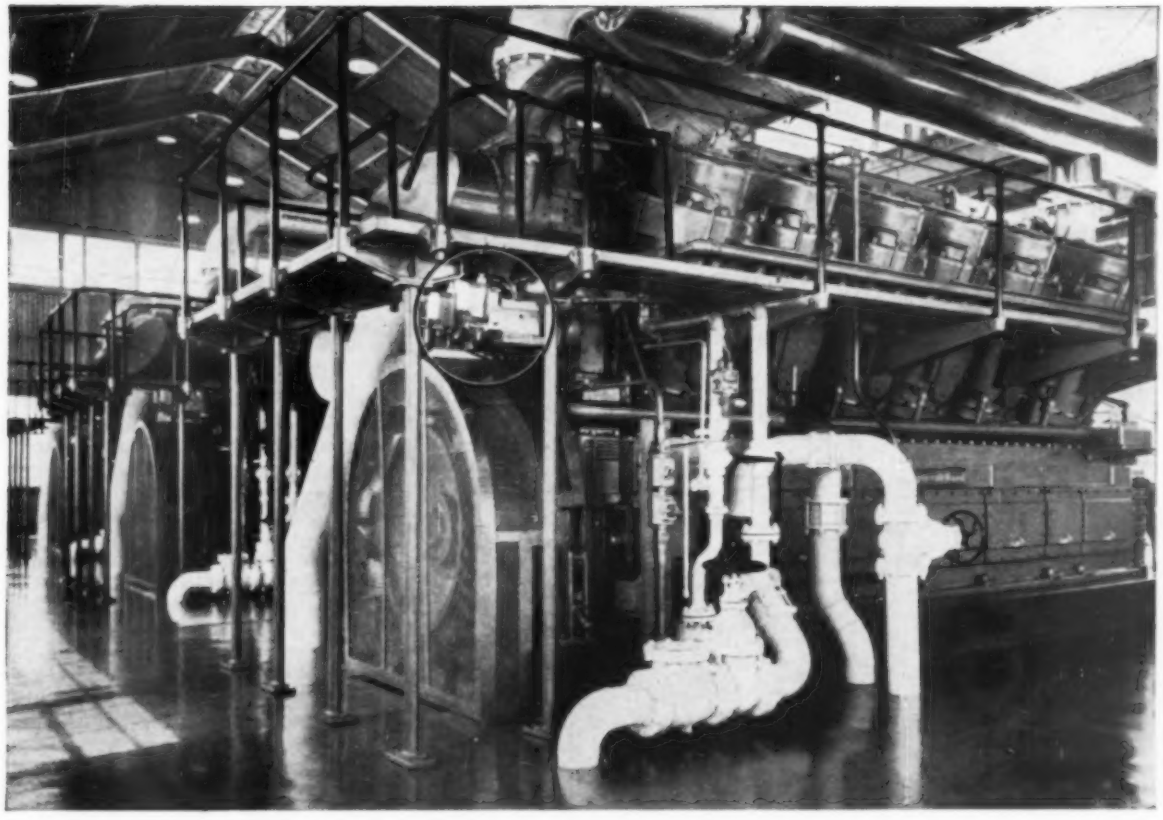

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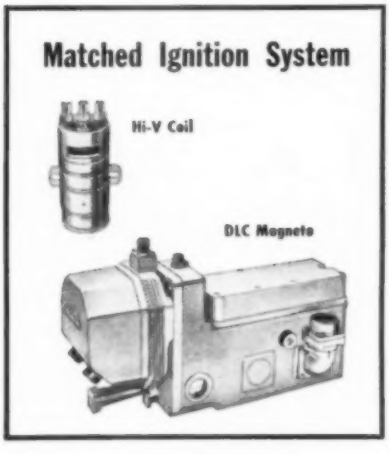

Trunkline Gas Company of Houston, Texas, operates a natural gas transmission line extending from near McAllen, Texas, to Tuscola in central Illinois where it connects with the line of the Panhandle Eastern Company.

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Helping to serve this very important segment of the nation's natural gas transmission system is the battery of Ingersoll-Rand 412 KVS engines equipped with Bendix DLC6 magnetos and Bendix HI-V transformer coils (illustrated at left) in Trunkline's Cypress Compressor Station near Houston.

The Bendix DLC6 magneto is a completely new type of magneto, incorporating the latest engineering design. Together with the Bendix HI-V transformer coil it becomes a matched ignition system that delivers more than ample voltage with greatly reduced maintenance cost.

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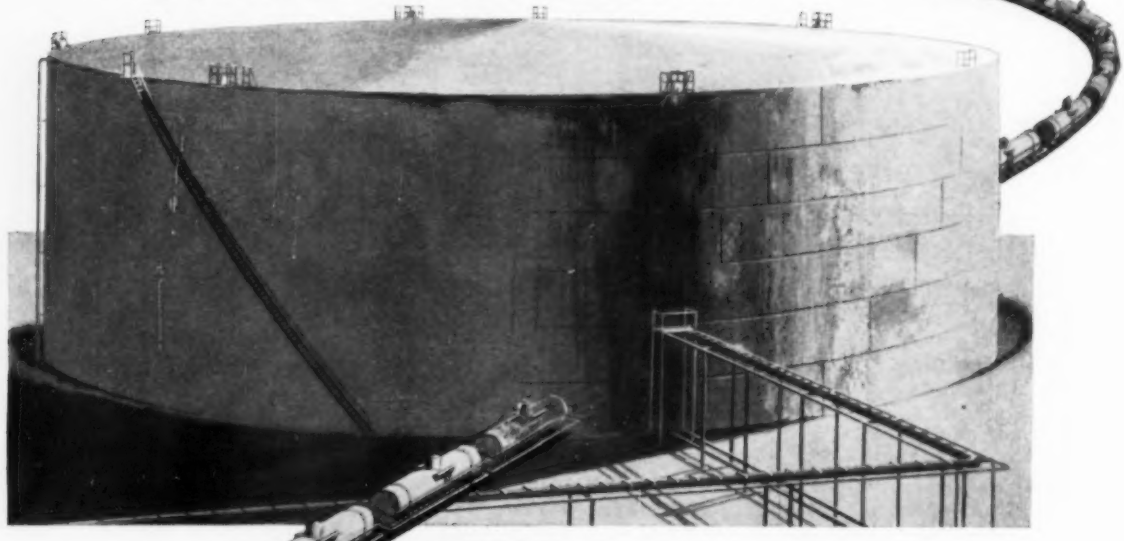

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PERSONALS

Sidney A. Swensrud, chairman of the board of Gulf Oil Corporation will retire April 23. He has had almost 30 years of active service in the oil industry. He began his oil career in 1928 with The Standard Oil Company of Ohio as executive vice president, then joined Gulf in 1947 in the same capacity. In 1948 he became president of Gulf and in 1953 chairman of the board.

Hines H. Baker will retire as director and president of the Humble Oil & Refining Company April 29. He will be proposed to the stockholders for election to the Standard Oil Company's (New Jersey) board of directors. If elected, Baker will succeed **J. E. Crane** to the Jersey board. Baker has been president and chief executive officer of Humble since May 1948.

Robert B. Dummett has been appointed a director of The British Petroleum Company Limited to fill the vacancy on the board caused by the resignation of **B. R. Jackson.** Dummett has been managing director of The Commonwealth Oil Refineries Limited, BP's marketing organization in Australia. **D. Anderson, A. E. C. Drake** and **C. E. Spearing** have been appointed directors of BP Trading Limited, The British Petroleum Company's principal trading subisidiary. **P. T. Cox** was made managing director of BP Exploration Limited.

R. B. Dummett

J. R. Getty

J. Ronald Getty was elected a director of Tidewater Oil Company to fill the vacancy left by the death of Fero Williams. Getty had served as managing director of Veedol G.m.b.H., Tidewater's marketing subsidiary in West Germany, with headquarters in Hamburg. In addition, he has been manager of export activities in Europe, the Middle East, and Africa.

Three new vice presidents have been named by Magnolia Petroleum Company. **George J. Gregor** is the new marketing vice president replacing **Guy L. Tate,** who is retiring. **Charles B. Wallace** is vice president and general counsel. **R. G. Sanders** is vice president and manager of refining. He succeeds **John W. Newton** who is also retiring. The new officers were made company directors. Another director named was **L. H. True,** president of Magnolia Pipeline Company. **M. W. Patterson,** company treasurer, and **E. J. Wacker, Jr.,** vice president of Magnolia Pipeline, were made assistant vice presidents. **Fred H. Pennington** will succeed Patterson as treasurer and assistant secretary of Magnolia Petroleum and Magnolia Pipeline. He has been manager of taxes and governmental reports and controller of Magnolia Pipeline. **E. M. Caldwell** succeeds him as manager of taxes and governmental reports.

Stanley L. Westlake, chief engineer, and **David H. Levy,** general superintendent of the communications and electrical department both of Magnolia Pipeline, have been named directors of that company.

Lewis Frensley, controller of Magnolia Petroleum was also made controller of Magnolia Pipeline. **C. S. Cone** is new assistant controller of that company.

Elmer D. Erney was appointed manager of the purchasing department in the headquarters office of Cities Service Company. He succeeds **John J. Dorr,** who has been appointed manager of trade relations. Erney formerly was purchasing agent for one of the principal Cities Service subsidiaries, Cities Service Oil Company, (Pennsylvania). He will be succeeded in that position by **Frank T. Whitty,** former assistant purchasing agent.

S. G. Sanderson was elected a vice president and **John S. Sprowls** was elected an assistant treasurer of Gulf Oil Corporation. Sanderson is division manager of the company's Tulsa production division. Sprowls was supervisor of loans and related investments.

H. C. Briggs, Los Angeles, California, was appointed assistant to Continental Oil Company's Rocky Mountain region general management, with headquarters in Denver, Colorado. He has been associated with Conoco at Los Angeles since 1927 and has held various key positions in the company's western region.

Dr. John E. Powers of the University of Oklahoma, has received an award from Socony Mobil Oil Company of a $4000 grant. He is an assistant professor of chemical engineering and received the award in support of his basic research in the field of thermal diffusion.

Standard Oil Company of California has consolidated its marine activities into a new management organization under the name of California Shipping Company.

A. E. Kihn, formerly manager of Standard's marine department, has been named president and director of the new company. Other directors are: **W. H. Beekhuis,** vice president, Standard of California; **H. A. Ervin,** vice president, California Tanker and California Transport; **L. C. Ford,** previously assistant manager, marine department; **F. C. Loomis,** vice president, Western Operations, Inc., and **B. W. Pickard,** president, The California Oil Company. Ervin and Ford will serve as vice president and general manager of the Atlantic and Pacific divisions, respectively.

Dr. Gerhard Herzog was appointed an assistant general manager of the research and technical department of The Texas Company.

B. D. Lee was named manager of exploration research and **K. C. ten Brink,** manager of production research.

John T. Snyder, Jr., was elected financial vice president of Pan American Petroleum Corporation. He will also serve on the Pan American board of directors. Snyder was formerly financial vice president, secretary and director of the Southern Production Company, Inc., Fort Worth, Texas.

Walter Dannenbaum was elected a member of the board of The Atlantic Refining Company. He will complete the unexpired term of **N. S. McCausland,** a director since 1946, who resigned. Dannenbaum has for many years been with E. I. du Pont de Nemours & Company serving as vice president, member of the executive committee, and a director of Du Pont.

Basil P. Kantzer and **Charles S. Parker** were elected vice presidents of Union Oil Company of California. Kantzer is manager of operations for Union's extensive Gulf division, with headquarters in Houston, Texas. Parker is director of economics and planning, with headquarters in Los Angeles.

Guy C. Kiddoo and **Robert S. Kerr, Jr.,** have been elected to the board of directors of Kerr-McGee Oil Industries, Inc. Kiddoo has been a general vice president of the First National Bank of Chicago, Illinois, for 25 years. Kerr is the eldest son of Sen. Robert S. Kerr, founder and chairman of the company. He is an associate in the law firm of Kerr-Conn-Davis in Oklahoma City.

G. C. Kiddoo

R. S. Kerr, Jr.

DEATHS

Max Davis, drilling contractor of Mt. Vernon, Illinois, was killed in an automobile accident recently.

Ira Emmett McCabe, chief engineer and chairman of the board of The Mercoid Corporation, died February 13.

Roy Lee, 61, secretary-treasurer of Hunt Oil Company, died March 5 after a brief illness.

Reuben J. Russell, vice president and a founder of Century Electric Company of St. Louis, Missouri, died February 11, following an operation. He was 81 years old.

Louis S. Clarke, last of the pioneers of America's automotive industry, died in his sleep January 6 at the age of 90.

Wendell G. Thayer, 52, executive director of the Pacific Oil Institute, died January 5.

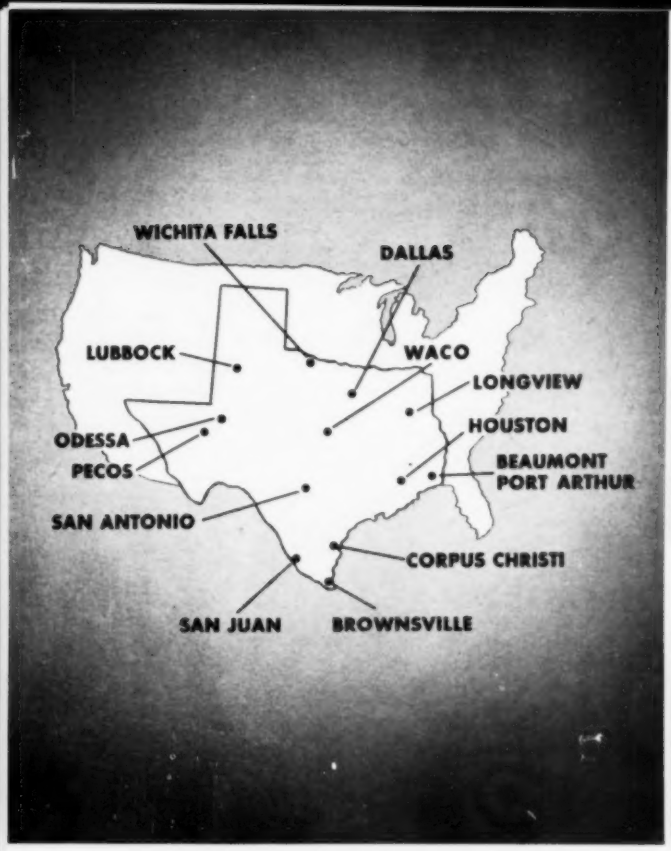
L. E. Ingham, 65, retired vice president of Texas Gas Transmission Corporation, died of a heart attack on March 3.

Harold Davis Skyrm, 59, vice president of General American Transportation Corporation, died February 24, following a heart attack.

Carol M. Buffington, 59, died March 7 after a five-month illness. He was supervisor of The Ohio Oil Company's refining and marketing accounting department.

Charles A. Chipman, oil producer and president of the Pennsylvania Grade Crude Oil Association died unexpectedly of a heart attack March 7.

Newton R. Graham, first vice president of the Arkansas Basin Development Association, died in his sleep of a stroke March 6.



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The Trade PARADE

FMC Acquires Oil Center Tool

Food Machinery and Chemical Corporation has acquired over 98 percent of the outstanding shares of Oil Center Tool Company of Houston, Texas. Transaction was completed by a share for share exchange of FMC common stock for the outstanding shares of Oil Center Tool. Incorporated in 1929, OCT is a major producer of wellhead equipment to control flowing oil and gas wells.

Officials say the new acquisition is a result of the company's planned expansion in the petroleum equipment industry. Oil Center Tool Company will function as an FMC subsidiary operation. No changes in management are contemplated.

LeTourneau Re-enters Earthmoving Field

Robert G. LeTourneau has announced that his firm will re-enter the earthmoving industry after a five-year absence. The company's earthmoving equipment business was sold to Westinghouse Air Brake in 1953.

New equipment will be marketed under a new trade mark "Ar-Gee" instead of the "LeT" or "LeTourneau" which has identifield LeTourneau equipment.

The company has been developing equipment for such fields as land clearing, off-road transportation, logging, heavy materials handling, offshore drilling, and other fields not related to earthmoving.

Five New Parkersburg Divisions Created

Under new organization plans, five separate divisions have been created for the Parkersburg Rig and Reel Company. Named to head the divisions were J. W. Robbins, general manager of the oil field sales division; C. D. Haehl, general manager of the pressure vessel division; W. J. Slaughter, general manager of the pumping unit division; J. Q. Callaway, manager of the special products division, and C. L. Wilson, general manager of the metal building division.

General sales offices will be in Fort Worth, Texas, as will headquarters for the oil field sales and special products divisions. Division offices for metal buildings, pressure vessels and pumping units will be at Parkersburg, Houston, Texas, and Tulsa, Oklahoma, respectively.

New regional sales managers for the pumping unit division include: C. M. Ferguson, northern region; G. W. Hendricks, southern region, and J. L. Norris, sales manager of the Canadian region.

W. H. Land is appointed sales manager for the pressure vessel division, and regional sales managers include Ralph M. Roberts, Gulf Coast region and J. D. Connor, West Texas-New Mexico region.

Regional sales managers for the oil field sales division named were L. R. Latimer of Parkersburg; J. M. Baldridge, Houston; M. L. McLafferty, Tulsa; B. D. McClelland, Odessa, Texas; W. L. Spawr, Los Angeles, California, and W. H. Fitzer, export manager at New York.

Drilco Oil Tools, Inc. has established a sales office in Houston with **Don Morris** in charge. Morris was formerly district field salesman with the company in West Texas. He has been with Drilco since its organization in 1953.

Don Morris

Oil Pioneers Memorialized

Pioneers who discovered and developed the great East Texas oil field were memorialized with the unveiling of a monument near the site of C. M. (Dad) Joiner's discovery well in Rusk County. The monument, a joint of pipe selected from the one-millionth ton of oilfield pipe manufactured by Lone Star Steel Company, is in Pioneer Park, a small plot of ground located on the Tyler-Henderson highway.

The joint of pipe was sealed with various newspapers, magazines, letters, maps, pictures, etc., along with 100 shares of Lone Star stock. It will be opened in 2056. Republic National Bank of Dallas will act as the trustee for all funds derived from the stock and these funds will be used to help worthy East Texas boys and girls obtain college educations.

Computer Laboratory Opened

Bendix Computer Division opened a Digital Computation Laboratory under the direction of Tak Yamashita, for the use of outside organizations. Located near the International Airport in Los Angeles, the laboratory is helping industrial clients solve many types of mathematical and engineering problems. Projects now in progress are in data reduction, aerial triangulation, potentiometer design, matrix inversion, pipeline construction and special research and development studies.

Esso Licensed to Use Dow Catalyst

Esso Research and Engineering Company is licensed to use The Dow Chemical Company's Type B catalyst and process for making butadiene. Esso Petroleum, Ltd., a British affiliate of Esso Research, plans to use the process at its new butadiene manufacturing facilities in Fawley, England.

Dow Type B catalyst is a calcium nickel phosphate material and is reported to offer a 20 percent increase in production efficiency. With modification of equipment, the catalyst can be used in present butadiene manufacturing plants.

Engineering-Construction Company Formed

Davidson-Kennedy Company has announced the formation of Davidson-Kennedy Associates. New firm will act as an engineer-contractor and will carry out the design, procurement of equipment and materials, and erection of chemical process plants and facilities. President of the new firm is Thornton Kennedy, also president of Davidson-Kennedy Company.

Five Million Feet of Log

Well logging operations of Hycalog, Inc. reached the 5,000,000 ft mark recently. Milestone was reached on a wildcat well being logged for California Company in Smith County, Mississippi. Logging unit used on the job is one of 44 trailermounted units operated by Hycalog throughout the U. S. and Cuba.

New Neutron Source

A new actinium neutron source developed by Well Surveys, Inc., Tulsa, Oklahoma, will be used in neutron logging instruments of Lane-Wells Company. Both companies are Dresser Industries' organizations. The actinium source emits a high neutron flux with a relatively small gamma ray emission which is considered optimum for logging accuracy.

Davison Completes Catalyst Plant. A new plant to produce reforming catalyst for petroleum refineries was completed by Davison Chemical Company, Division of W. R. Grace & Company, at Curtis Bay, Baltimore, Maryland. Capacity of the new facility is approximately double that originally projected. The reforming catalyst is platinum on alumina.

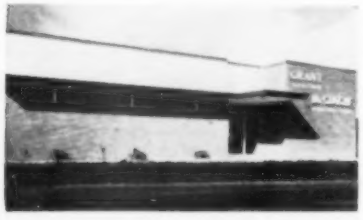
Business Up — Plants Expand

Sherman Products, Inc. is adding about 30 percent more floor space to its plant and offices on West Fourteen Mile Road, Royal Oak, Michigan. Most of the new space will be used for production of Sherman power diggers.

Emsco Screen Pipe Company, manufacturers of oil well and water well screen pipe since 1923, has completed its new plant and office building on the outskirts of Houston, Texas. The shop facilities cover 20,000 sq ft with modern equipment and machinery for handling pipe and processing it on a production line basis.

A new, modern sulfuric acid plant will be built by the **Du Pont Company** on the Detroit River at Ecorse, Michigan, about eight miles south of Detroit. Replacing an existing plant, new unit will substantially expand production over the present facilities.

Branson Instruments, Inc. and its subsidiary, **Branson Ultrasonic Corporation,** moved into a new plant in Stamford, Connecticut. Starting in two rooms of an old frame house, a little over 10 years ago, the company now has 24,000 sq ft of working floor space in this new facility. Branson is best known for its ultrasonic testing instruments — the "Audigage" and the "Vidigage" — and a complete line of ultrasonic power devices.



Grant Oil Tool Company and its affiliate, **MacClatchie Manufacturing Company,** have completed new, expanded quarters at Lafayette, Louisiana. The modern, streamlined building houses the shop, a warehouse and the offices. Branch complements other established Gulf Coast facilities in Harvey, Louisiana, and Houston, Texas.

S & R Tool & Supply Company, Houston, Texas, has completed an 11,000 sq ft addition to its plant. This separate building is being utilized for materials storage and layout shop.

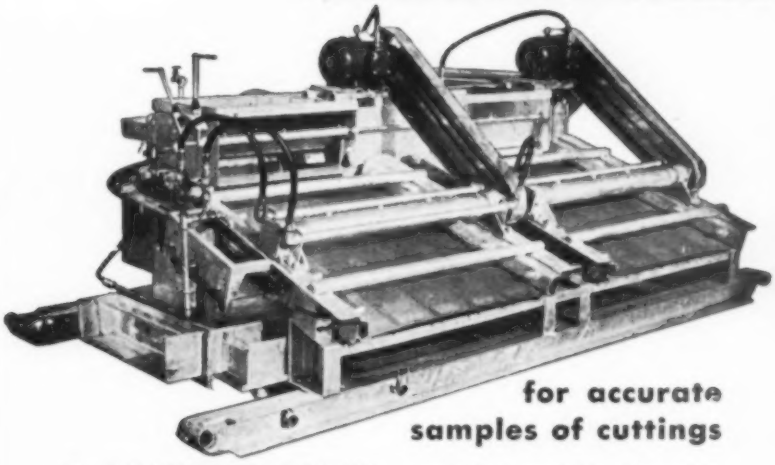
Completed addition to the **Rust-Oleum Corporation** plant, located in suburban Evanston, Illinois, marks the eighth company expansion project within the past 10 years for the rust-preventive manufacturer. Rust-Oleum administrative and manufacturing facilities are planned around a center park area which boasts special landscaping and flower gardens to blend with the suburban atmosphere.

Servomechanisms, Inc. has signed a contract for the construction of a plant in Westbury, Long Island, New York. Curtain wall construction is planned in order to achieve high flexibility for production areas, permitting fast and inexpensive changes in layout if necessary for expansion purposes.

A new million dollar plant to produce oil industry chemicals will be built by **Visco Products Company,** a unit of National Aluminate Corporation at Sugar Land, Texas, adjacent to Visco's plant No. 1. Plans call for completion about January 1958. Crude oil emulsion breakers, refinery desalting chemicals and anti-corrosion chemicals are scheduled to be manufactured in the new plant.

Thompson

DOUBLE VIBRATING SHALE SHAKER...and SAMPLE MACHINE



for accurate samples of cuttings

The THOMPSON SHALE SHAKER SAMPLE MACHINE offers the operator and geologist one of the best methods available for obtaining accurate foot-by-foot samples of well cuttings.

This THOMPSON DOUBLE VIBRATING SHALE SHAKER and SAMPLE MACHINE is specially engineered for off-shore barges or islands, deep wells, or wells using big volume and high pressure mud pumps. It is available either plain or galvanized, which makes it rust and deterioration-proof on off-shore or coastal duty

THOMPSON Shakers are famous for their highly efficient service at any depth or flow and for their economical first cost.

Make sure THOMPSON'S on the job for accurate samples and clean mud.

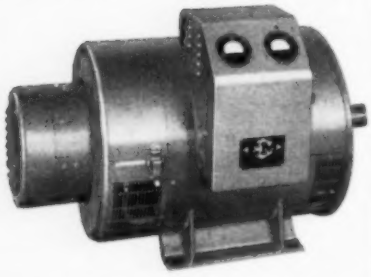
SOLD ONLY THROUGH SUPPLY STORES

Thompson TOOL CO. IOWA PARK, TEXAS

Power on tap!

A NEW 5 TO 50 KW "PACKAGED" GENERATOR

REG-AMP



REG-AMPS are available for 1800 and 1200 rpm operation, single- or 3-phase power, at all standard low voltages. REG-AMP shown has single bearing. Two bearing units are also offered.

It's a complete source of a-c electric power and the perfect mate for your engine

REG-AMP is a revolving field a-c generator with direct-connected exciter, built-in automatic voltage regulator, and a-c ammeter and voltmeter. It's factory assembled, internally connected, and tested.

Regulates voltage automatically. Simple relay constantly senses output voltage and keeps it right for best operation of your motors, lights, and electronic equipment.

Positive voltage control. Voltage can be adjusted to compensate for line voltage drop or normal engine speed droop under heavy load.

Starts big motors fast! Coordinated regulator design gives quick response.

Easy to install, simple to operate. Fully self-contained. Requires no switchboard. Merely couple to engine and connect to load thru suitable switch.

Needs little maintenance. Only an occasional check for cleanliness and brush wear.

Fabricated steel frame. Rigid, dripproof frame keeps REG-AMP safe, clean, and dry.

Performs smoothly. Every design is painstakingly engineered. REG-AMP is a product of 50 years of E-M Generator experience.

Get more information from your nearby E-M Sales Engineer. Also, write E-M for publication PRD-246 . . . it gives complete REG-AMP ratings.

E-M

2100-TPA-2102

ELECTRIC MACHINERY MFG. COMPANY
Minneapolis 13, Minnesota

Largest manufacturer of "Packaged" Generators

NEWS NOTES

EXPANSION OF THE FACILITIES OF All-Power Mfg. Company of Montebello, California, and the election of L. G. Evans as vice president and general manager have been announced. Evans was formerly assistant to the president of Emsco Manufacturing Company, a division of Youngstown Sheet and Tube Company.

RESEARCH PARTNERSHIP HAS been formed between Ionics, Incorporated, of Cambridge, Massachusetts, and Diamond Alkali Company, Cleveland, Ohio. Under the arrangement, Ionics will devote all of its uncommitted research efforts to Diamond's interests.

A $1,500,000 EXPANSION PROGRAM announced by Berkeley Division of Beckman Instruments, Inc. will triple production capacity.

DOWELL INCORPORATED HAS opened a general sales office in Denver and has formed a new district in New Mexico, Arizona, Utah, and Colorado. E. H. Nielsen, formerly manager of Dowell's Denver district, will head the new office as general sales engineer. R. R. Wagner is Farmington district manager; P. J. "Pete" Millar, district sales manager, and E. A. Tulley, district office manager.

JENSEN ENGINEERING COMPANY of Tulsa, Oklahoma, has moved into a new building at 53rd and Garnett Road. Building houses both the company offices and manufacturing plant with expanded facilities for production of tank mixers for the oil industry.

BERRY DIVISION OF OLIVER IRON and Steel Corporation, which merged recently with Oliver Tyrone Corporation, has changed its name to Berry Hydraulics.

REVERSING THE TREND OF FIRMS to move from city to suburbs, the Thor Power Tool Company has transferred its executive offices from Aurora, Illinois, to downtown Chicago. All executive officers in management and sales headquartered at the Aurora plant are involved in the move.

New Company Makes Cathodic Rectifiers

Electronics International, Inc., a new Houston, Texas, company, will design, manufacture and market rectifiers for the protection, by impressed current, of buried and submerged metal structures.

Officers include Wayne A. Johnson, president; Ted Riseling, vice president in charge of sales, and J. H. Reynolds, vice president and secretary.

Earth Drill Business Acquired

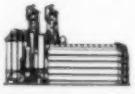
Mobile Drilling, Inc. has purchased the earth drill business of the Buda Division of Allis-Chalmers Manufacturing Company. Inventories are being moved to the mobile drilling plant in Indianapolis, Indiana. Acquisition substantially increases the range of models and sizes of earth drilling equipment offered by Mobile.

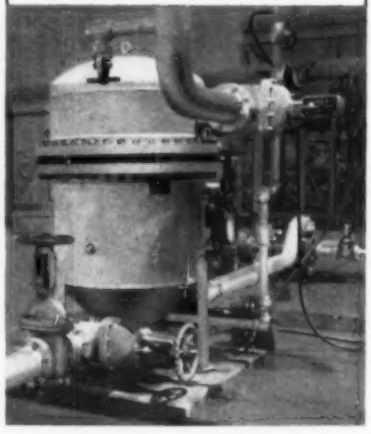
Tulsa Firm Opens New Office

Seismograph Service Corporation, world-wide seismic firm, opened its new $900,000 Tulsa, Oklahoma, headquarters. Personnel and equipment from seven separate Tulsa locations were moved, marking the first time the Tulsa organization has been under "one roof." The main building, a two-story structure, houses SSC's general offices, seismograph, LORAC and other electronic laboratories.

"DE-GUNK" AMINE SOLUTIONS

—more efficiently
—in less space
—at less cost





only STELLAR® FILTERS give you all these advantages—

1. **Removal of finest solid corrosion products**
2. **Longest useful solution life**
3. **Maximum capacity in minimum space**
4. **Exclusive gas-bump cleaning eliminates backwashing, simplifies waste disposal**
5. **Shortest off-stream time for cleaning**
6. **Rugged corrosion-resistant construction**
7. **Simplicity of operation and maintenance**
8. **Flexibility of design pressure and size**

These and other important advantages are inherent in the distinctive design of the "STELLAR" filter, for conservation of your amine solutions. Write today for complete information and Bulletin No. 1560-B.

Inquiries and samples are invited on all problems in the treatment of waters and wastes for the petroleum and related industries.

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INCORPORATED
General Offices • Tucson, Arizona • P.O. Box 5033
Field offices throughout the United States and in foreign countries

THE ONLY COMPANY impartially offering equipment for ALL types of water and waste processing: coagulation, precipitation, sedimentation, flotation, filtration, ion exchange and biological treatment.

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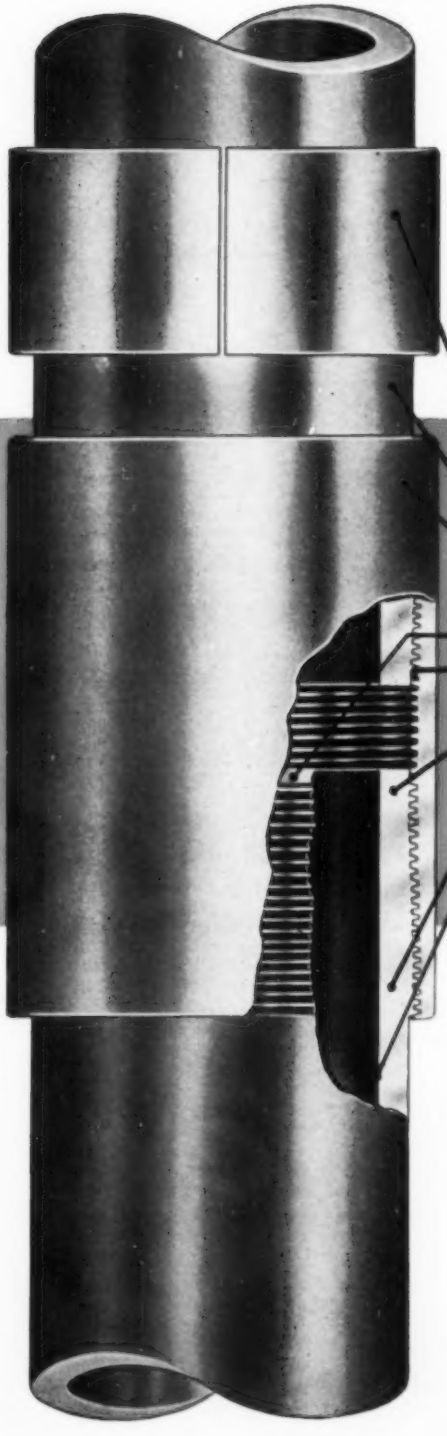
LINE PIPE and WELL TUBING



Now Distributed in the Oil Country by

CONTINENTAL-EMSCO

The only commercially tested, high pressure and corrosion-resistant non-metallic pipe on the market is now available through your Continental-Emsco store.

Fibercast has many desired advantages found in no other non-metallic pipe. Over five years of actual field applications have proved its superiority and durability.

Ask a Continental-Emsco representative for full details on Fibercast.

8 reasons for Fibercast superiority!

1. Wrench ring (optional)
2. Standard O.D. pipe size
3. Coupling stronger than the pipe
4. Entry lead for easy make-up
5. Molded threads
6. Epoxy coating seal on all cut ends
7. Multiple layer braided glass reinforcement
8. Smooth interior with a Hazen-Williams C Factor-147

plus Complete line of fittings
Superior chemical resistance of Epoxy Resins

FIBERCAST is made from Thermosetting Reinforced Epoxy Resins —*not to be compared with Extruded Plastic Pipe made with Thermoplastic Materials!*

For Descriptive Bulletin Write, Box 359, Dallas, Texas

MANUFACTURED BY

THE FIBERCAST CORPORATION

A Subsidiary of The Youngstown Sheet and Tube Company

CONTINENTAL-EMSCO

Serving the Oil and Gas Industries ... Worldwide

CONTINENTAL-EMSCO COMPANY

A Division of The Youngstown Sheet and Tube Company

General Offices: DALLAS, TEXAS • Plants: LOS ANGELES • HOUSTON • GARLAND, TEXAS

Representatives in All Principal Oil Fields of the World

PEOPLE

Clair A. Spahn is now service engineer for Bucyrus-Erie Company in five east-central states and Ontario, Canada.

Phil Thomas has been appointed to the newly-created position of export sales representative of the export division of Magnet Cove Barium Corporation.

Russell Brittingham, vice president and director of purchases of Corning Glass Works, has been named president of Pittsburgh Corning Corporation. He succeeds **H. B. Higgins,** chairman of the board of Pittsburgh Plate Glass Company.

Walter E. Barnes has been appointed district manager of the newly-created Panhandle district of the midwest division of The National Supply Company.

M. L. Talbert has been appointed chief engineer for Security Engineering Division, one of the Dresser Industries.

Charles W. Mitchell has been named vice president of the Stauffer Chemical Company and general manager of the Nyotex Chemicals Division.

William T. Taylor has been elected chairman of the board of ACF Industries, Incorporated, effective April 1, 1957.

Vincent J. Calise has been appointed general sales manager of Graver Water Conditioning Company.

J. Robert Simpson, III, has been appointed sales manager for Conoflow Corporation.

Harry E. Porter has been appointed southwestern manager of Foamglas industrial insulation sales.

William J. Alexander has been appointed manager of the sales promotion department of Continental-Emsco Company, a division of Youngstown Sheet and Tube Company.

Joe R. Robinson has been appointed manager of Middle West Coating & Supply.

R. O. Moore

W. A. Sellers

J. P. Jones

G. B. Blair

Mid-Continent Supply Company has promoted four men. They are: **R. O. Moore,** general manager of buildings and construction; **W. A. Sellers,** general merchandise manager; **J. P. Jones,** assistant to general division manager, and **G. B. Blair,** assistant to general manager of sales.

William L. Butler has been elected president of W. C. Norris Manufacturer, Inc. Announcement was made by **E. C. Bolger,** retiring president.

W. L. Butler

W. C. Browning

William C. Browning has been named research director of the Milwhite Mud Sales Company. He will head all phases of research and development.

John C. Linsenmeyer, formerly president of the American Blower and Ross Heat Exchanger Divisions, has been elected executive vice president of American-Standard. **John W. Brennan** was named president of American Blower Division, and **Richard S. Reade** is now president of Ross Heat Exchanger Division.

James E. Henning has been appointed vice president of Bjorksten Research Laboratories for Industry, Madison, Wisconsin. **Irvin Leichtle** has been named administrative assistant.

W. Earl Dunn is now vice president-general manager of Chemical Plants Division of the Blaw-Knox Company. He was previously with J. F. Pritchard & Co.

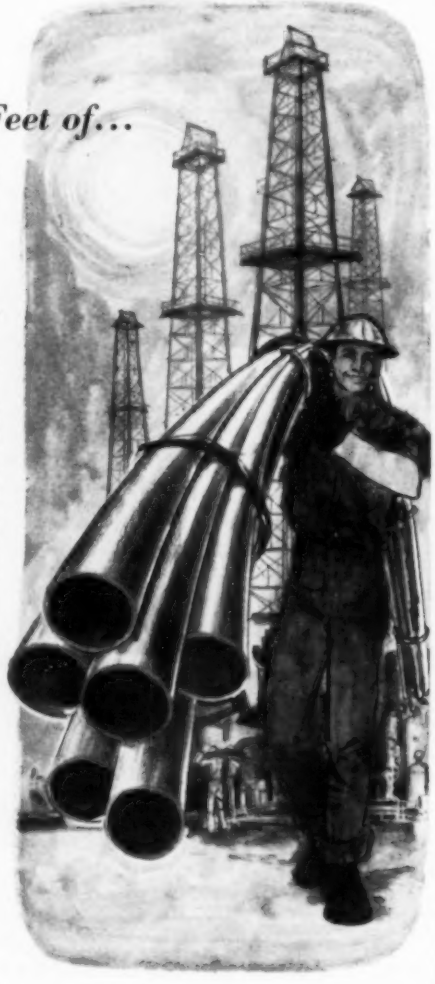
Over One Million Feet of...

KRALOY

HIGH-IMPACT

PVC PIPE

in oil-country use today



This proves that there is no substitute for Kraloy experience.

KRALOY is the most experienced manufacturer of PVC plastic pipe for the petroleum industry. The first polyvinyl chloride lead line installed in this country—at Great Bend, Kansas—was Kraloy Pipe. Kraloy High-Impact PVC today is preferred by production men for maintenance-free service in lead lines and disposal systems. Kraloy customers use Kraloy High-Impact PVC pipe for lead lines, gas lines, and salt water lines because Kraloy normally eliminates (1) sulphur corrosion due to sour crude, (2) paraffin buildup, (3) corrosion and scale, (4) trouble from soil electrolysis.

YOU Benefit From KRALOY'S Quality Control

To insure quality control, random samples of Kraloy Plastic Pipe are tested daily in Kraloy's own laboratory for burst pressure, impact resistance, and tensile strength under standard ASTM specifications.

Kraloy Pipe is Sold Only Through Qualified Supply Stores

Warehouse stocks and sales representatives:

Great Bend, Kansas:
Robinson Oilfield Specialties Co.,
616 Main St.

Houston, Texas:
The Mott Company,
1719 McKenney St.

Tulsa, Oklahoma:
The Becker Sales Company,
2837 Sands Spring Rd.

For case histories of actual Kraloy installations, cost comparison tables between Kraloy and other pipe, plus detailed instructions and specifications for all field uses, write to:

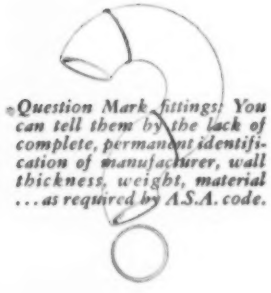
KRALOY *plastic pipe co., inc.*

4720 East Washington Boulevard, Los Angeles, Calif.

Subsidiary of the Seamless Rubber Co., a **Rexall Drug Co.** Subsidiary

KP-102

Why try to cut corners with *Question-Mark** fittings?



**Question Mark fittings: You can tell them by the lack of complete, permanent identification of manufacturer, wall thickness, weight, material . . . as required by A.S.A. code.*

Unknown welding fittings are as risky as unmarked turns on a busy highway. These blind spots in an expensive piping project cause slow-downs, confusion, trouble . . . waste time and money.

"Question Mark" fittings may look like a bargain on the price tag, but watch out for the after-costs . . . poor fit-up, impaired quality, questionable supply, lack of engineering service! Your reputation is at stake!

A message in the interests of top quality piping . . . by Tube Turns, Louisville, Kentucky.

HOW TO SAFEGUARD YOUR REPUTATION

He knows he's getting the exact fitting specified on the blueprint because each TUBE-TURN product is clearly marked with all designations.

Save manhours...avoid piping risks with known fittings

You save purchasing time, get prompt delivery, speed up installation, and help assure reliable piping performance when you specify TUBE-TURN* Welding Fittings and Flanges. They meet all American Standard and Safety Code requirements. Each product is permanently marked with complete size and material designation. Your nearby Tube Turns' distributor gives you prompt delivery from the complete-line stock, and makes available Tube Turns' unmatched engineering service.

You *know* your piping investment is safeguarded when you specify and buy Tube Turns' products.

Your nearby Tube Turns' Distributor meets your needs promptly from the complete line of more than 12,000 Tube Turns' stocked items.

The Leading Manufacturer of Welding Fittings and Flanges

TUBE TURNS LOUISVILLE 1, KENTUCKY

A Division of National Cylinder Gas Company

DISTRICT OFFICES: New York • Philadelphia • Pittsburgh • Chicago • Detroit • Atlanta • New Orleans • Houston • Midland Dallas • Tulsa • Kansas City • Denver • Los Angeles • San Francisco • Seattle

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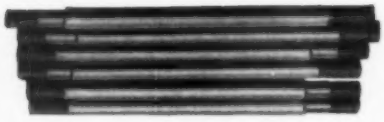
*"TUBE-TURN" and "tt" Reg. U. S. Pat. Off.

Pump rods hard-faced by ThermoSpray Process give 20 times longer service



New Metco Process hard-faced acid sludge pump rods serve as much as 20 times longer than unfaced rods.

A number of oil companies are making important savings in equipment down-time and replacement part costs with the METCO THERMOSPRAY® Hard-Facing Process. Typical of these parts are pump sleeves, as well as the acid sludge pump piston and rods shown here. Operating conditions were severe—rods had to be replaced every 24 hours—new packing every 8 hours. Hard-faced rods now last over 500 hours; packing more than 60 hours. Coatings are extremely dense and non-porous—homogeneous.

The THERMOSPRAY Hard-Facing Process consists of spraying specially developed alloys in powder form with the METCO THERMOSPRAY GUN. No compressed air is required. Coatings have hardness of Rc 30 to Rc 65, depending on the specific THERMOSPRAY alloy used; will outwear hardened steels from 3 to 10 times. Spraying speeds are higher—8 to 10 lbs. per hour—and deposit efficiency far greater (up to 97%)—than with any other type of available equipment. Hard surface depth can be closely controlled and the smooth surface left after spraying requires a minimum of finishing.

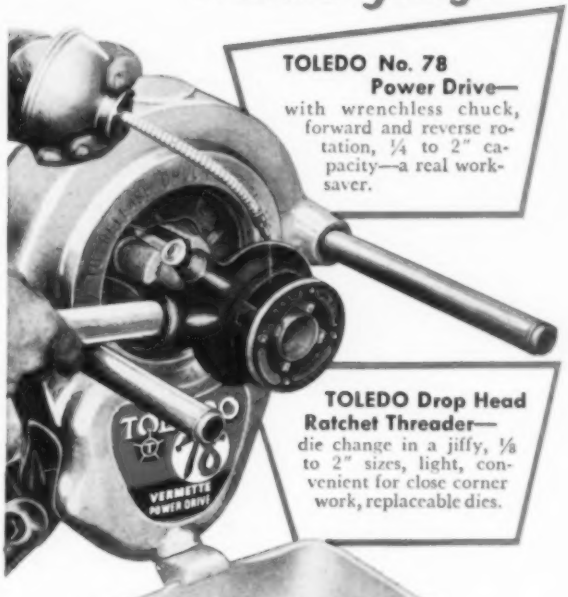
Write today for free descriptive Bulletin 126A or a call by a full-time, company-trained, Metco Field Engineer in your territory. Or see your local metallizing job shop.

The following trade names are the property of Metallizing Engineering Co., Inc.: METCO®, ThermoSpray.
®Reg. U.S. Pat. Off.

Metallizing Engineering Co., Inc.
1149 Prospect Ave., Westbury, L. I., New York • cable: METCO
In Great Britain: Telephone: EDGEWOOD 4-1300
METALLIZING EQUIPMENT COMPANY, LTD.—Chobham near Woking, England

PORTABLE POWER THREADING

Ready to go...
wherever you go



TOLEDO No. 78 Power Drive— with wrenchless chuck, forward and reverse rotation, ¼ to 2" capacity—a real work-saver.

TOLEDO Drop Head Ratchet Threader— die change in a jiffy, ⅛ to 2" sizes, light, convenient for close corner work, replaceable dies.

Take the toil out of threading . . . this chuck locks pipe or conduit in place—with one finger tightening. Just put the pipe in the wrenchless chuck, "finger" tighten, turn the switch and you're ready to go. Team the No. 78 with a TOLEDO Drop Head Threader and your threading jobs are turned out in seconds. See these TOLEDO-quality products at your supplier's today!

Send for complete information.

THREADED PIPE
it's tight—it's leak-proof—it's best—costs less

BUILDERS OF THE WORLD'S FINEST PIPE TOOLS
TOLEDO®
PIPE THREADERS • PIPE WRENCHES • PIPE MACHINES

THE TOLEDO PIPE THREADING MACHINE CO. • TOLEDO 4, OHIO

A CAT* TWIN ARC-WELDER JOINS THE FIRING LINE

for Oklahoma Pipe Line Constructors

Oklahoma Pipe Line Constructors put its new Caterpillar D315 Twin Arc-Welder to work immediately on a 24″ line it is laying for Tennessee Gas and Transmission Co. into the northeastern states.

The great new arc-welder—which combines a powerful Cat D315 Engine with two welding generators mounted in one generator frame—is mounted on an Athey crawler pulled by a D6. Reports Superintendent N. L. Arie:

"We like Caterpillar equipment because we have found it best over the years. Cat-built equipment takes more rough treatment in tough places than any other."

And the new twin arc-welder is no exception. It is heavy-duty power in a compact package—easily transported over rugged terrain. The unit is only 30″ wide and 10′ long. Each of the two generators has an output of 300 amperes, but when extra-heavy current is required, they are paralleled to produce 600 amperes. Independent controls allow operators to weld at different voltages at the same time.

Welders like the smooth arc with its excellent metal flow. And you can be sure your firing line will keep up with the pipe. This 4-cycle diesel picks up the load instantly without missing.

Here's a way to cut transportation and maintenance costs and conserve manpower. You'll start saving money the day you begin using the new twin arc-welder on your spread. For complete details, see your nearby Caterpillar Dealer soon.

Caterpillar Tractor Co., Peoria, Illinois, U.S.A.

CATERPILLAR*

*Caterpillar and Cat are Registered Trademarks of Caterpillar Tractor Co.

MODERN HEAVY-DUTY PIPELINE WELDERS

PEOPLE

D. W. Vernon

H. V. Heuser

D. Schmeeckle

Douglas W. Vernon has been named product sales manager for wire rope and aircord by John A. Roebling's Sons Corporation.

Henry V. Heuser was elected president of the Henry Vogt Machine Co. He succeeds his father, **G. A. Heuser,** who became chairman of the board.

Duane Schmeeckle is new representative in Canada for Rolo Manufacturing Company. Schmeeckle's firm, Petro-Automation Industries Limited, headquarters in Edmonton, Alberta.

H. E. McGower, Jr.

M. G. Cook

O. W. Barnett

Changes announced by Camco, Incorporated are: **Paul R. Mills,** president and chairman of the board; **E. K. Watters,** vice chairman of the board; **H. E. McGowen, Jr.,** executive vice president and general manager; **W. M. Edwards,** secretary and treasurer. **Pat Childs** is general sales manager under **Sam Pearce,** vice president of sales. **H. H. Moore** was named chief engineer, and **Charles Nevels** moved to Houston as Gulf Coast division manager.

Marshall G. Cook has joined Rockwell Manufacturing Company as assistant product manager — liquefied petroleum gas products. **Herbert M. Logan** is now manager of distributor sales and **Orville W. Barnett** has been named Tulsa, Oklahoma, district manager.

L. C. Daniels

W. F. Kruger

R. M. Smith

L. C. Daniels is general manager of the Buda Division, Tractor Group, Allis-Chalmers Manufacturing Company. He succeeds **R. K. Mangan,** president and general manager, Buda Division, who retired.

William F. Krueger is manager of pipeline sales for Dresser Manufacturing Division, Dresser Industries.

Robert M. Smith has been named general sales manager of Eastman Oil Well Survey Company. Before joining Eastman, he was with Cardwell Manufacturing Company.

The Fluor Corporation, Ltd. has promoted **J. L. Tathwell** and **F. G. Crawford** to the newly created position of manager of projects. All active contracts will be assigned to a manager of projects for overall management and coordination.

Refined
. . . but
RUGGED!
Yes, You Get . .
Precision Control . . .
with Line Scale
WEIGHT INDICATORS
• for Work-Overs!
• Packer Setting!
• Well Servicing!
Field-proven over the years for precision and durability, Line Scale Weight Indicators give you the correct, computed weight of the load . . . instantly, accurately . . . in pounds! Any change in number of lines is compensated for by relocating the shoe-clamp. In sizes from 40,000 to 500,000 . . . quickly and easily installed!
Readings calibrated in pounds!
Not affected by temperature!
Fully mechanical—no hydraulic system to maintain!
Easily read, illuminated dials!
Built right—Priced right!
A Size to Fit Every Job!
Stocks maintained in principal oil field areas. Sold through your local supply store.
Line Scale
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Oklahoma City
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FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

LAUGH with BARNEY

"How much sleep do you ordinarily require?" asked the doctor.

"About five minutes more."

* * *

"She only cares for platonic love."

"What's that?"

"It's like tip-toeing down to the cellar for a bottle of home-made root beer."

* * *

The kid, aged five, was muttering to himself as he dressed in the morning.

"Hmmm," he said, "button gone off—and right in the busiest place, too."

The difference between faith and knowledge is illustrated by an old Negro preacher.

"Now, my brethren," he said, "it's like dis. Dar's brudder Johnsing asittin' on de front seat wid sister Johnsing and de five little Johnsings. She knows dat dey is her children — dat's knowledge. He believes dey is his children—dat's faith."

* * *

We've read so much about the effects of drinking that we've decided to give up reading.

POWERED by a small but extremely rugged Model BKN single cylinder Wisconsin Heavy-Duty Air-Cooled Engine (6.8 hp.), this pumping unit circulates and recirculates bad oil or bottom settlings through the treating plant, to pull from the test tanks and general transfer work. The unit comprises a Wisconsin BKN Engine with reduction assembly, direct-connected to a Roper rotary pump, and is operating on a major oil company's 14,500 ft. well in Grady County, Okla. The 185 ft. mast in the background is one of the most modern and highest in deep well drilling.

In Big League operations such as this, involving possibly an investment of a quarter of a million dollars or more, the engineers must of necessity investigate and specify only the most select equipment to best meet the job requirements. Wisconsin Air-Cooled Engines score high on the "select" list for every type of service within their horsepower range (3 to 56 hp.).

Wisconsin Air-Cooled Engines and Harley Sales Company units are specified as most compatible with the best equipment used in deep well operations . . . backed by service second to none! Let us prove it to your satisfaction.

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MILWAUKEE 46, WISCONSIN
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OIL FIELD DISTRIBUTORS FOR WISCONSIN ENGINES AND ALL TYPES OF UTILITY UNITS

"Will there be anything else, sir?" the bellhop asked, as he made the lady and gentleman comfortable.

"No, thanks," answered the man.

"Anything for your wife?"

"Why, yes," the man replied, "bring me a postcard!"

* * *

After feeling ill for several days, a young lady of questionable reputation went to see a doctor.

When the examination was completed, he patted her shoulder and confidently told her, "don't worry about a thing, I'll have you back in bed in a week."

* * *

Prosecuting Attorney: "You mean to say you had 16 beers and didn't move once from the table the night of the murder?"

* * *

1st Hen: "Have you been giving that rooster any special encouragement?"

2nd Hen: "Oh no — I just egg him on a little."

* * *

Clem was driving down the road to town one Wednesday morning. He passed a field where his friend Frank was plowing.

"Mornin, Frank," Clem hailed as he slowed down.

"You going to town in the middle of the week?" asked Frank.

"Yep, going after the preacher. Mary's got to get hitched."

"Who done it?" Frank asked.

"My hired hand, Joel."

"Ain't he the one that busted yore plow last spring?" asked Frank.

"Yep."

"Clumsey, ain't he."

* * *

Sympathy: What one girl offers another in exchange for details.

* * *

Two silk handkerchief boys were riding around in their sports car when a big truck suddenly stopped in front of them and they crashed into the rear of it.

The pansy got out of the sports car, took off his tam and sun glasses, walked over to the burly truck driver and punched him on the nose, turned around, walked back to his car, put on his tam and his sun glasses and drove off.

His companion pulled at his sleeve and said, "Tomboy."

* * *

Eight-year-old William came home from school one day with a very sad look on his face. He moped around the house until his dad came home. Dad asked him what was wrong and William answered; "I failed in spelling today."

"What word did you miss?" Dad asked.

"Posse."

"No wonder you missed it, you can't even pronounce it."

* * *

The woman entered the bookshop and spoke to the clerk.

"Do you have a book on birds and bees for my little boy?"

"Madam," the clerk replied," do you mean one of those 'facts of life' books?"

"Look," the woman said, "I've been pregnant six times since he was born so he ought to know the score by now . . . what HE wants to know about are the birds and the bees!"

* * *

When the grocer's little girl came home after a holiday at her aunt's, she found that triplets had been added to the family.

"How silly of you, mammy," she said, "you should have done the ordering—you know how daddy stutters!"

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

SENTINELS . . . These Rockwell-Nordstrom valves stand always ready for fast, easy operation. No matter how long a Rockwell-Nordstrom valve has been in open or closed position, *operation is instant*. Why? Pressurized lubricant in the exclusive Sealdport* system acts as an hydraulic jack to keep the plug free for smooth, easy quarter-turn operation and the same pressurized lubricant forms a lasting, *double seal* against leakage of lightest gases or heaviest slurries.

Where your valves must be sentinels against trouble . . . year after year . . . specify Rockwell-Nordstrom valves. They cost no more to buy, often less, than ordinary valves. Their dependability has been proved through forty years of exceptional performance in every industry. Rockwell Manufacturing Company, Pittsburgh 8, Pa. *Registered trade mark Rockwell Manufacturing Company.

Available at leading suppliers . . . everywhere.

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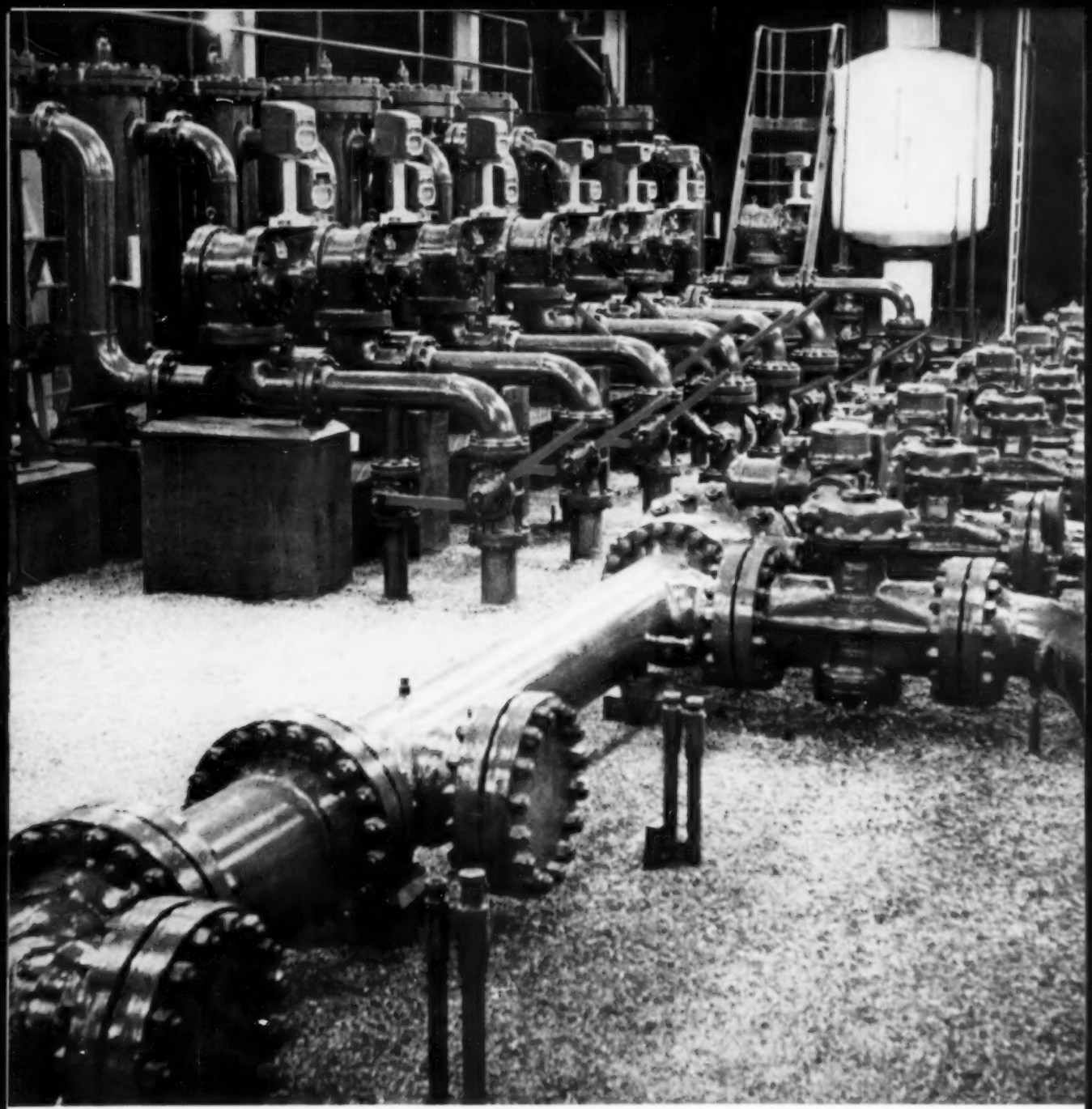
Nordstrom
VALVES

Lubricant Sealed for Positive Shut-Off



COMPACT DESIGN SAVES MONEY when you specify Rockwell-Nordstrom valves for tight manifolds like at the pipeline station above. (Rockwell Rotocycle meters are also shown.) Most Rockwell-Nordstrom valves take little more area than the diameter of the flanges—there are no bulky rising stems or cumbersome bonnet cavities. And less bulk means less weight too; that's another cost cutting bonus you gain for intricate piping arrangements in modern process plants.

You'll also save product loss and contamination because Rockwell-Nordstrom valves are lubricant sealed to be truly leakproof and to shut-off positively. From every standpoint, Rockwell-Nordstrom valves cost less to use and perform better. And they cost no more to buy, often less, than ordinary valves. Rockwell Manufacturing Company, Pittsburgh 8, Pa.

Available at leading suppliers . . . everywhere.

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Lubricant Sealed For Positive Shut-Off

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GENERAL CATALOG NO. 57

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- ★ Pipe Tools
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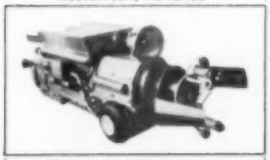

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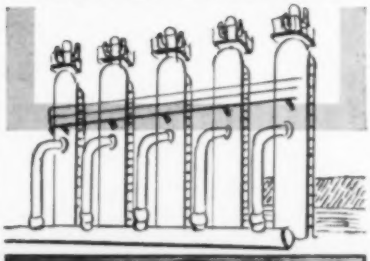

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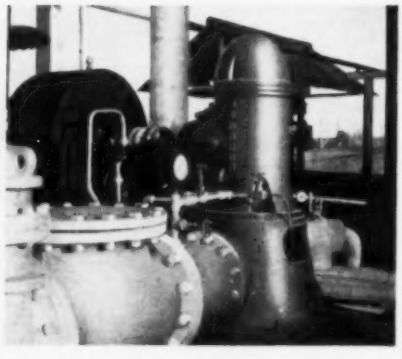

Photo Shows: Cooling Tower Application At Levelland, Texas

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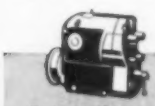
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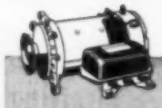
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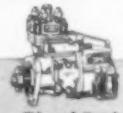
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And Auto-Shift tables put *more draftsmen* to work in available space. Designed for row installations, there's a reference desk behind each draftsman. *Six* men work where *four* do now! Get the whole story—write Auto-Shift, Hamilton Manufacturing Company, Two Rivers, Wisconsin.

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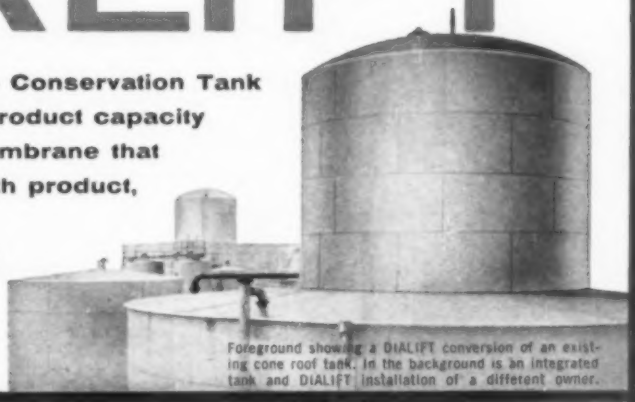
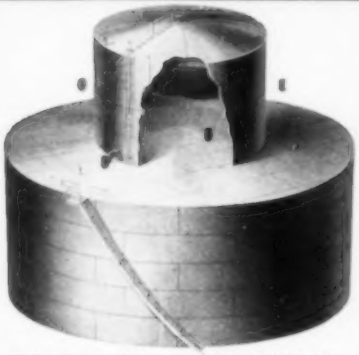
The HAMMOND DIALIFT

The ONLY membrane type Conservation Tank with full-rated vapor and product capacity AT ALL TIMES, with a membrane that cannot come in contact with product, vapor space that can be isolated for inspection and maintenance without taking product storage tank out of service.



Foreground showing a DIALIFT conversion of an existing cone roof tank. In the background is an integrated tank and DIALIFT installation of a different owner.



Principle of the Hammond Dialift

A— DIALIFT DIAPHRAGM rises and falls to accommodate expanding and contracting vapor.
B— Vapor passes to and from tank and DIALIFT through simple elbow connection.
C— DIALIFT and tank have full-rated capacity.
D— Membrane can't come in contact with product.
E— DIALIFT can be isolated for maintenance and inspection, product tank stays in service.

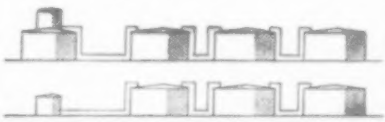
The most efficient and economical vapor conservation system for new or old tanks.

THE HAMMOND DIALIFT consists of a gas-tight Vulcalock membrane attached to the inside periphery of a cylindrical metal housing to become a "breathing" apparatus to accommodate the expanding and contracting vapor as developed in product storage tanks. The DIALIFT can be used as a single conservation unit by being attached to the roof of a product storage tank or as a central "breathing" system by being manifolded to a number of product storage tanks. There are two forms of installation: —Ground type manifolded to a number of tanks to form a conservation system and integrated type whereby the DIALIFT is attached to the roof of a product tank for vapor conservation for one or a number of tanks.

The DIALIFT is completely isolated from the product storage tank. Vapor passes between the tank and DIALIFT through a vaporline connection. It is easy to convert old cone roof tanks to efficient vapor-saving DIALIFT installations by attaching a DIALIFT housing with membrane to the roof of the old tank and connecting the vaporline between the tank and DIALIFT.

New or converted DIALIFT tank, inter-connected with cone-roof tanks, becomes central "breathing" unit.

DIALIFT GROUND UNIT serves as central "breathing" apparatus of multi-tank conservation system.



The HAMMOND dialift eliminates breathing loss and reduces filling loss

Other HAMMOND Bulletins describe these individual types of tanks: Floating Roof, Diaflote,* Vaporlift, Field Erected Unaerground, Elevated Water Tanks and Standpipes, Low Pressure, Bulk Storage.

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—the latest addition to the pipeline field

Job-tested in the West Virginia mountains, the No. 572 lays 26-inch pipe under the roughest possible conditions.

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Torque converter drive
Constant power drive to pipelayer winches
19-inch ground clearance
Hydraulic bottom-pivot counterweights
86-inch track gauge
Heavy-duty track rollers
Safety-engineered controls

The new CAT* No. 572 pipelayer, with its 86,000-lb. lifting capacity, is the machine you need to team up with the 130,000-lb.-capacity No. 583. Like its bigger brother, already established as the leader in the pipelaying field, the No. 572 is all pipelayer—an integrated unit of tractor chassis and pipelayer mechanism.

This pipelayer is the result of extensive field tests. With its 19-inch ground clearance and its 86-inch track gauge, the No. 572 gives you stability in any type of terrain. And it is powered by a dependable Cat Diesel Engine rated at 128 HP at 1200 RPM.

Maintenance is easy. Tracks are hydraulically adjusted so only a hand-grease gun is needed to maintain proper tension on the tracks. The box-construction center section of the pipelayer is easily removed for access to the clutch and transmission.

Operators will like its ease of operation and safety features. The No. 572 has in-seat starting. Controls are located for convenience and positioned for frequency of use. To prevent accidental dropping of the boom, the boom brake is spring loaded and requires a positive effort against the spring to release it.

The No. 572 is the newest addition to Caterpillar's full-line of equipment for pipeline spreads. It is designed for the tough jobs, wherever big-inch pipe may take you. Call your Caterpillar Dealer. He'll demonstrate it on *your* job . . . at *your* convenience.

Caterpillar Tractor Co., Peoria, Illinois, U. S. A.

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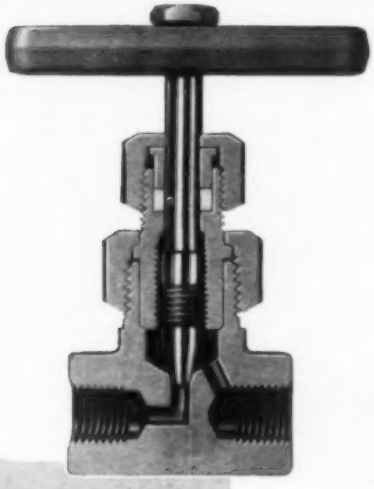
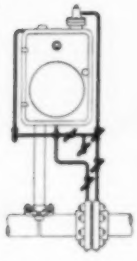
THE HARD WORK

For corrosive field service...

AMERICAN® Needle Valves





Teflon-packed, forged steel American® Needle Valves stand up in the toughest meter manifold jobs and other corrosive field services without gland leaks. Stainless or carbon steel precision machined valve bodies are specially suited for welding. Stainless steel centerless-ground valve stems are designed so that the valve can be repacked under pressure.

Standard valves design rated for pressures to 5,000 psi at 70°F. For pressures to 10,000 psi, upon request, valves are hydrostatically tested and individually inspected. Valves are furnished with graphite-impregnated asbestos packing for temperatures above 450°F.

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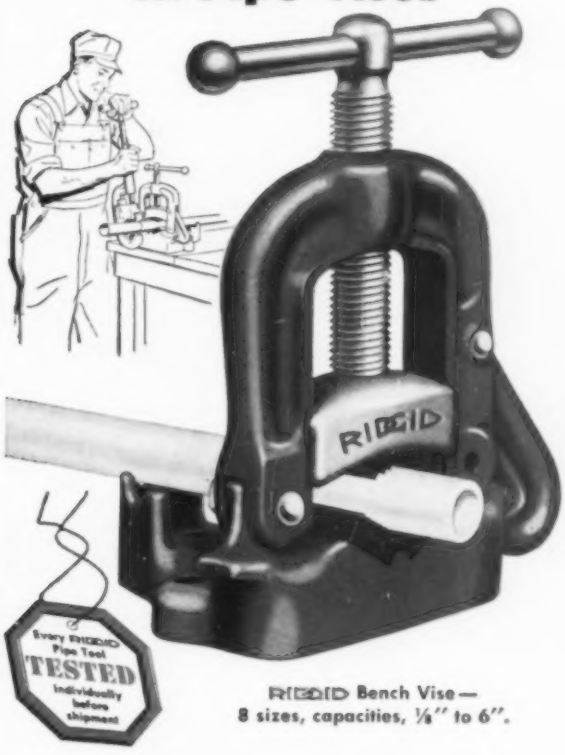

RIDGID Bench Vise— 8 sizes, capacities, ⅛" to 6".

It pays you to see the popular RIDGID line of Pipe Vises before you buy

Special work-saver features on every one— LonGrip jaws that grip tighter without chewing up pipe . . . pipe rests that hold pipe firm for better threading . . . handy built-in pipe benders . . . modern streamline design for efficient operation, yoke and chain— bench, stand, post models. More for your money when it's a RIDGID —order from your Supply House!

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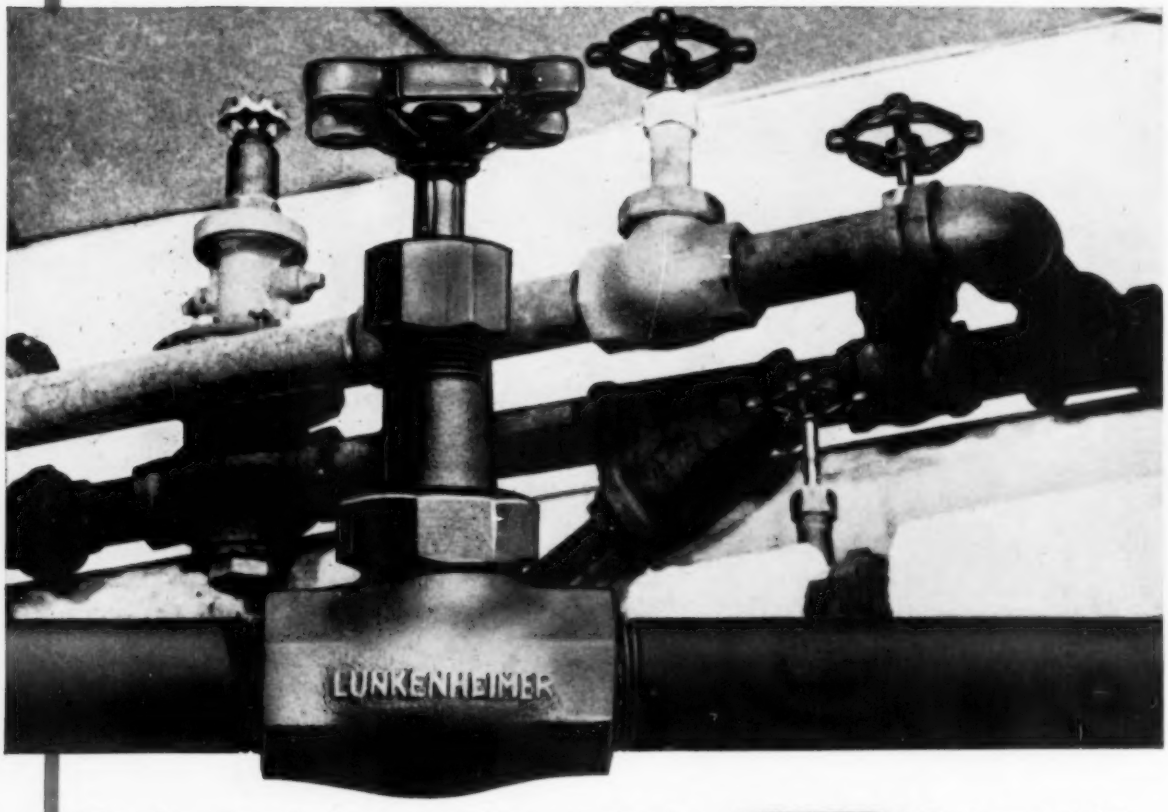
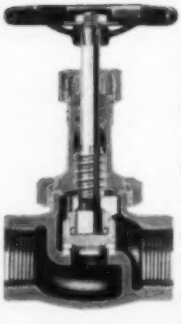
RIDGID Work-Saver Pipe Tools

Don't let LOW-QUALITY drain away YOUR *Maintenance* DOLLARS

The cost of a LUNKENHEIMER VALVE *Gets smaller... and smaller... and smaller...* with each passing year of dependable service.



The price you pay for the average valve represents only a fraction of its total cost. Every time a valve requires repair, more and more of your precious maintenance dollars are drained away. With today's high labor costs, it takes only one or two repair jobs to spiral maintenance expense up to a point many times higher than the original price of the valve. That's why it always pays to install the best valves your money can buy. When you insist on the extra margin of good workmanship and quality materials that go into Lunkenheimer Valves, you get your investment back many times over in trouble-free, maintenance-free service. The Lunkenheimer Company, Cincinnati 14, Ohio.



There's a cost-minded Lunkenheimer Distributor in your area. Let him show you how Lunkenheimer quality can contribute to valve maintenance savings in your plant. And be sure to check the amazing performance records of LQ600, with patented Brinalloy® seats and discs.

L-357-18

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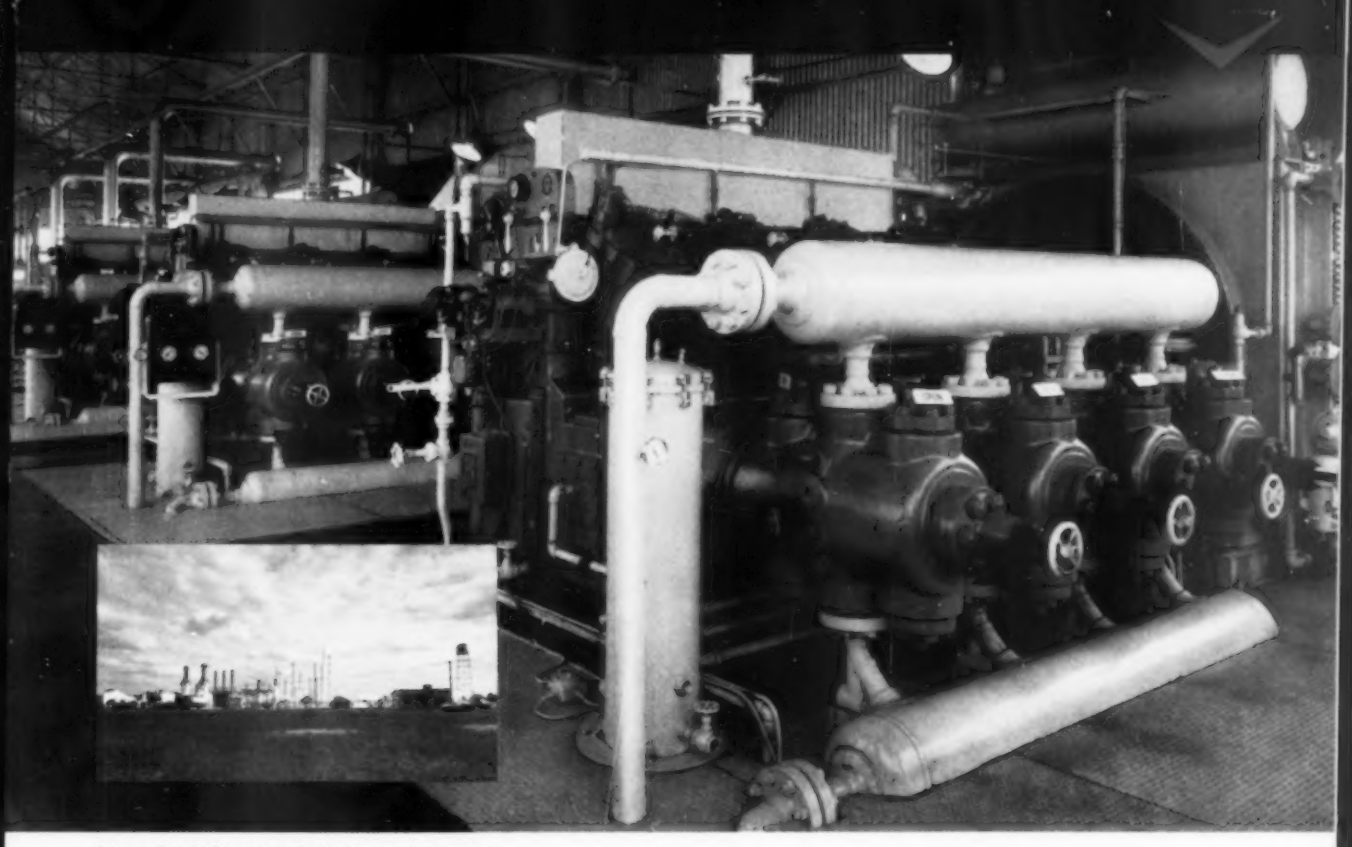
LUNKENHEIMER®

THE ONE *Great* NAME IN VALVES

BEAIRD-INGERSOLL-RAND Packaged Compressor Plant



Arkansas Fuel Oil Corporation's Panola Gasoline plant equipped with three Beaird-Ingersoll-Rand 220 h.p. 8JVG packaged compressors. Units have Young radiators with lubricating oil coolers and gas after-coolers and all necessary controls for unattended operation. Other sizes 110 to 660 h.p.

Packaged Compressors provide—

FLEXIBLE OPERATION FOR LARGE GASOLINE PLANT

Arkansas Fuel Oil Corporation operates this large gasoline plant in the Panola Field just south of Carthage, Texas. Natural gas processed in the plant is picked up from 18 wells by three Beaird-Ingersoll-Rand 8JVG 220 h.p. packaged compressor units. Boosting 8 to 12 million cubic feet per day the units use one stage of compression to raise the gas from 550 psig input to 1100 psig.

To assure maximum flexibility and continuous operation, Arkansas Fuel Oil installed a number of packaged units rather than one large compressor of equal horsepower. Plant pressures and operations can be maintained, when necessary, by two of the units while the third is shut down for maintenance or repair. This permits plant production to be held to scheduled capacity at all times.

As wellhead pressures drop off the compressors can be changed on location to two-stage operation or additional units can be placed on the line. The operating flexibility of this multiple unit packaged compressor station will prove even more valuable as the field approaches depletion. When no longer needed the compressors can be transferred to other service as complete units with little or no change.

Let us show you how economically Beaird-Ingersoll-Rand packaged compressor plants can be added to your compressor station.

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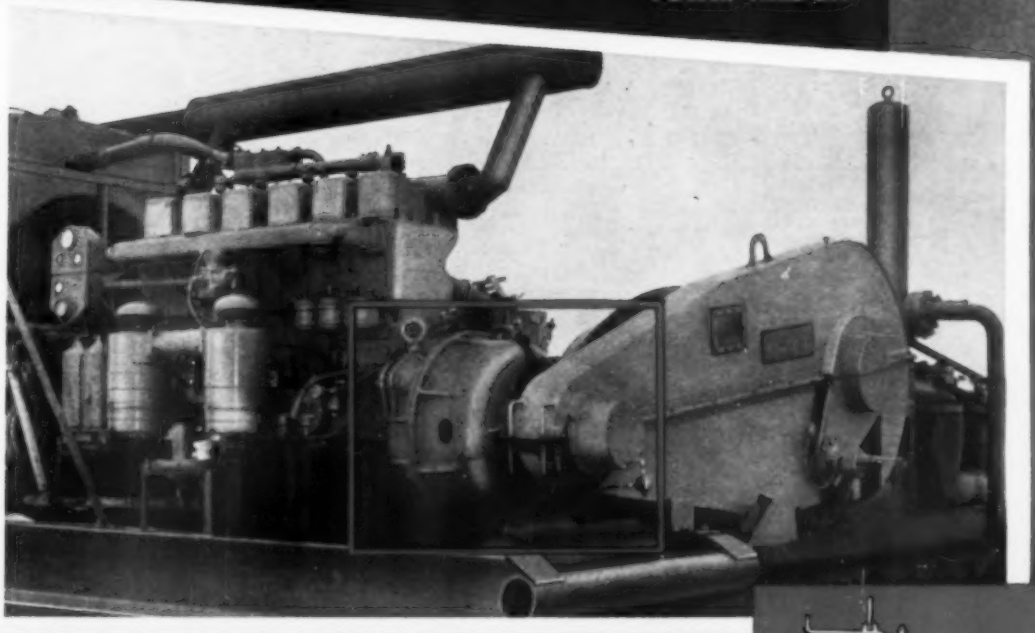
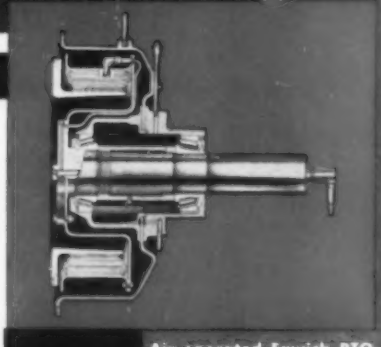
Air Controlled Shock-Free Operation with FAWICK PTO*

*POWER TAKE-OFF

Another Field-Proved Product Supplied by Mid-Continent



The air operated Fawick Power Take-Off provides an ideal shock-free independent pump drive and may be remotely controlled from the driller's position. Heavy duty bearings and rugged bell housing eliminate the need for pilot bearing or outboard bearing. The Fawick PTO offers dollar savings in initial installation too, because it requires no special adapters, skids or outboard bearings. It bolts directly to the engine flywheel and flywheel housing. V-belt or chain drives are easily installed or removed from the open end clutch shaft, speeding up rig-up time. For complete information on the Fawick PTO, contact your Mid-Continent representative. Mid-Continent stores, sales offices and sales representatives are located in all active oil areas.



Air operated Fawick PTO has self-adjusting CB air-flex clutch and rugged anti-Friction shaft bearings.

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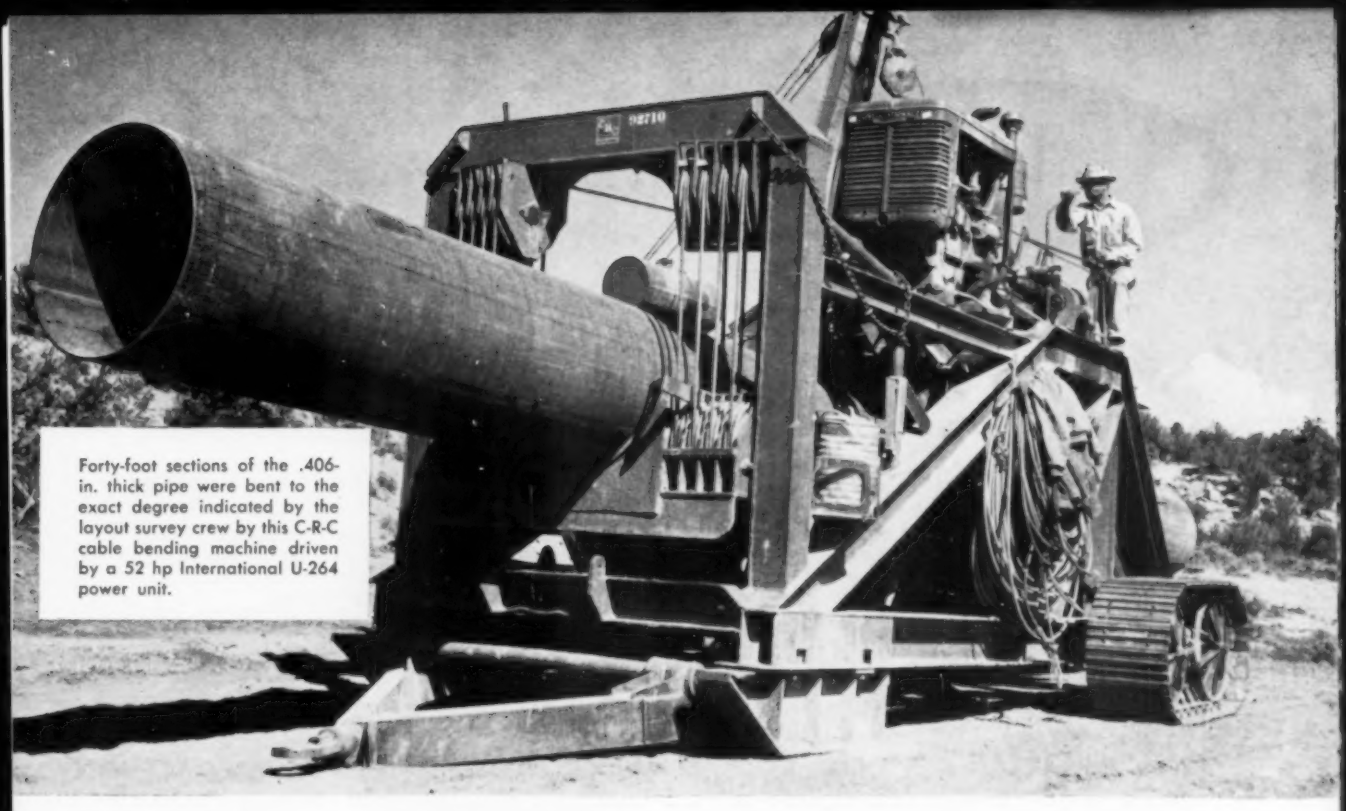


Forty-foot sections of the .406-in. thick pipe were bent to the exact degree indicated by the layout survey crew by this C-R-C cable bending machine driven by a 52 hp International U-264 power unit.

Power Units beat desert heat

preparing pipe on new 34-in. line

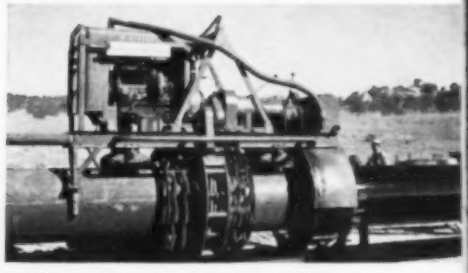
El Paso Natural Gas Co. speeds spread with rugged trio of International-powered C-R-C machines

Laying a 34-inch pipeline through the New Mexico heat at a two-mile-a-day clip is quite a feat. But that's what an El Paso Gas Co. spread did in completing a 17-mile section of the new line carrying gas from the San Juan Basin to consumers in California.

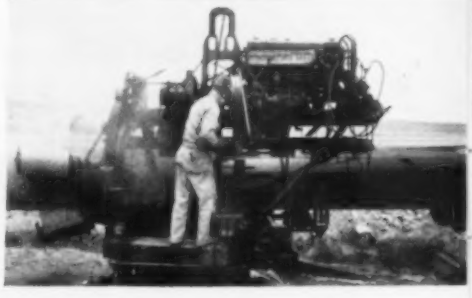
Plenty of the credit for the lively pace maintained by the spread goes to three International-powered C-R-C pipe bending, cleaning, and wrapping machines that beat the desert wind and weather and speeded the spread all the way.

Whether you drill, pump, or pipeline, you can get this same dependable engine performance by specifying one or more of 16 International carbureted or diesel power units. Internationals range from 10 to 200 hp and they give you bonus production from your powered machines, at lowest cost, too. See your always-available International Power Unit Distributor or Dealer soon.

The wrap-up operation moved swiftly as the C-R-C wrapping machine crept steadily down the 34-in. pipe. An International U-164 power unit is the source of power.



Welded and tested pipe gets a dope coating from a C-R-C doping machine driven along the pipe by an International U-372 power unit.



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If ever there was *one* public relations tool that contained all the key materials needed to build goodwill, THIS IS IT! It's the Oil Information Committee's new *Community Program Package*. And with it you can become one of the best known oilmen in your town.

Among the materials in this package you'll find something to interest every group in your community—school, farm, and women's groups; youth, civic, professional, fraternal and church organizations. Included are speeches and films, radio scripts and press releases, special demonstrations and hints on how to hold contests, stage parades, and hold "oilman for a day" events. It is the *complete* "goodwill builders" guide!

Of course you needn't be reminded how important goodwill is . . . both for you, the oilman, and your industry as well. It's a fact—the more people get to know you the more friends you make. And in your town you can help your business and your industry by telling your neighbors how petroleum helps serve their needs.

So why not take advantage of this professionally prepared, readymade community relations program. You can get your *Community Program Package* by working with the Oil Information Committee in your area:

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I am interested in building better public relations in my community. Please send me the address of my nearest Oil Information Committee District Office.

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FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

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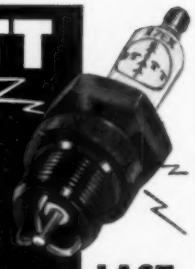

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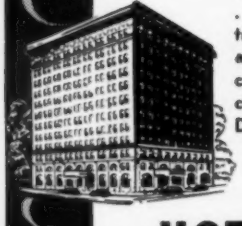

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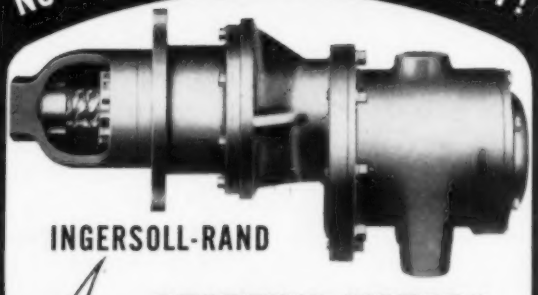

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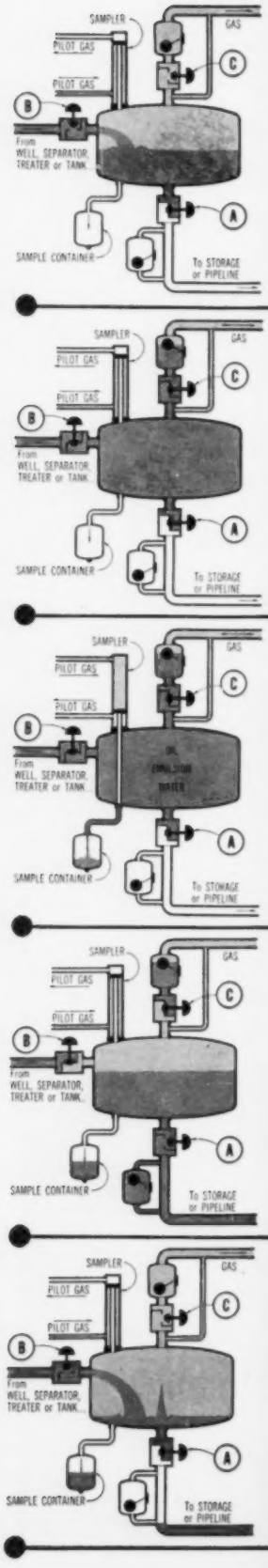

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The PVM* meter is liquid packed, sampled, and then counted as the liquid is discharged. Its accuracy is indisputable as to volume of liquid measured at the pressure-temperature condition of operation.

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**PVM and Core Barrel Sampler are the trademarks of National Tank Company*

- **FILLING** — Valve **A** is closed to retain liquid in metering chamber. Valve **B** is open to admit liquid and Valve **C** is open. The Sample Barrel is up out of the stream.
- **POSITIVE VOLUME ISOLATION** — Valve **A** is still closed; meter fills past Valve **C** which closes. Valve **B** closes, assuring meter to be full of liquid. Note the volume trapped by Valves **A**, **B** and **C** is positive and not affected by float control levels.
- **CORE BARREL SAMPLING OF LIQUID** — Valves **A**, **B** and **C** are closed. Sample tube is driven vertically through the liquid, assuring a representative, proportional sample of the entire content as it exists in the vessel. Sample is discharged to a container for future analysis. Sampler is retracted.
- **DISCHARGING AND RECORDING** — Valve **A** now opens permitting vessel to empty the positive volume. The cycle counter is actuated. Valves **B** and **C** are still closed.
- **VALVES REPOSITION** — Valve **A** closes; Valve **C** is opened, dropping fluid into meter for measurement with next volume and Valve **B** opens for new cycle.

Write for Tank Topics on Metering Equipment

NATIONAL TANK COMPANY

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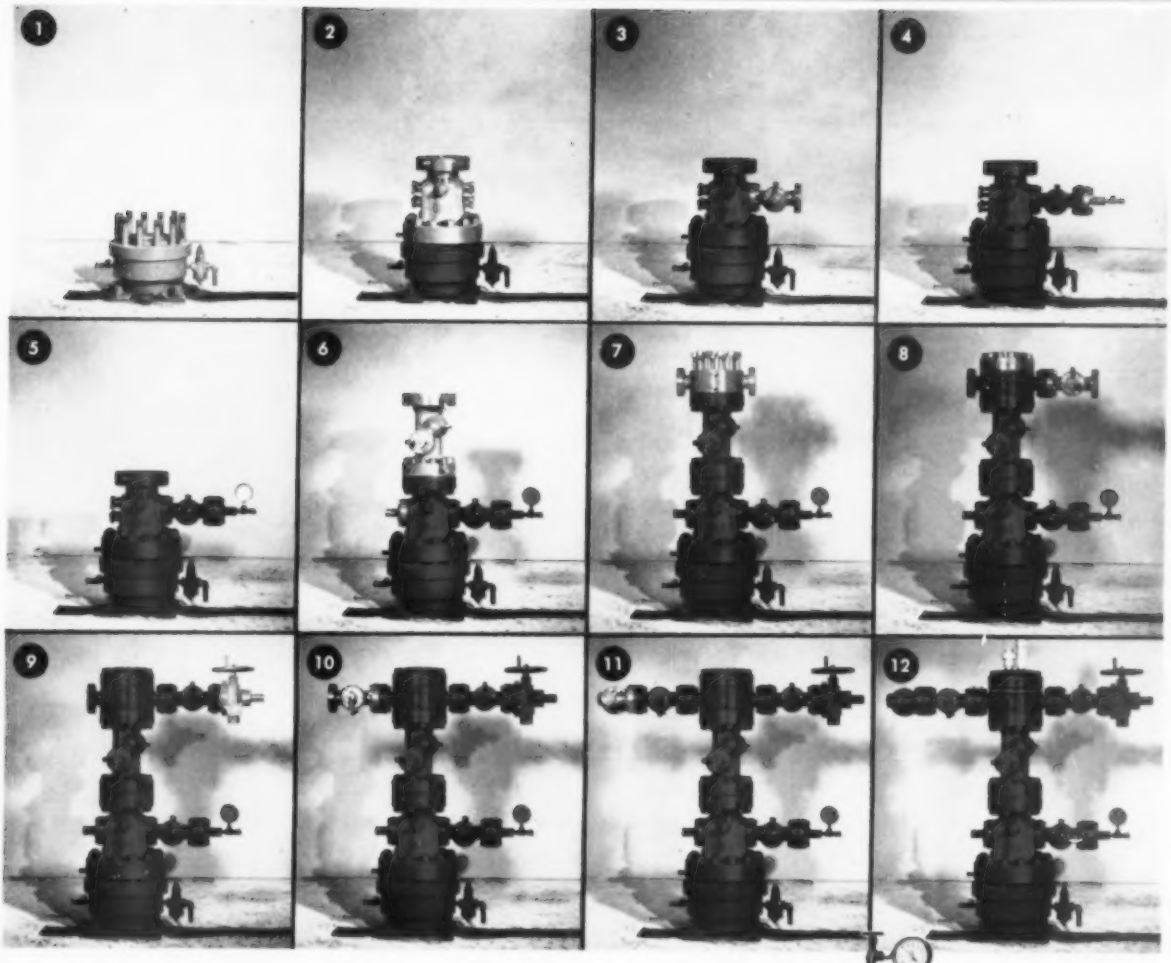

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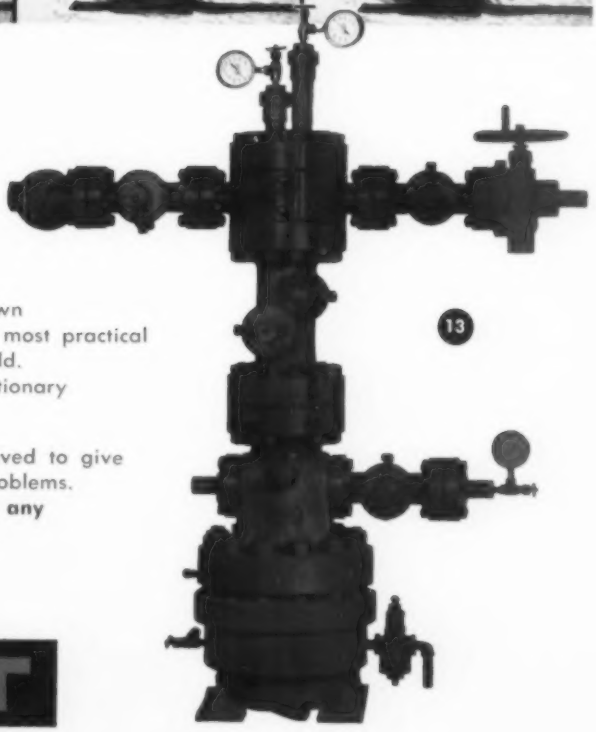

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Houston, Texas

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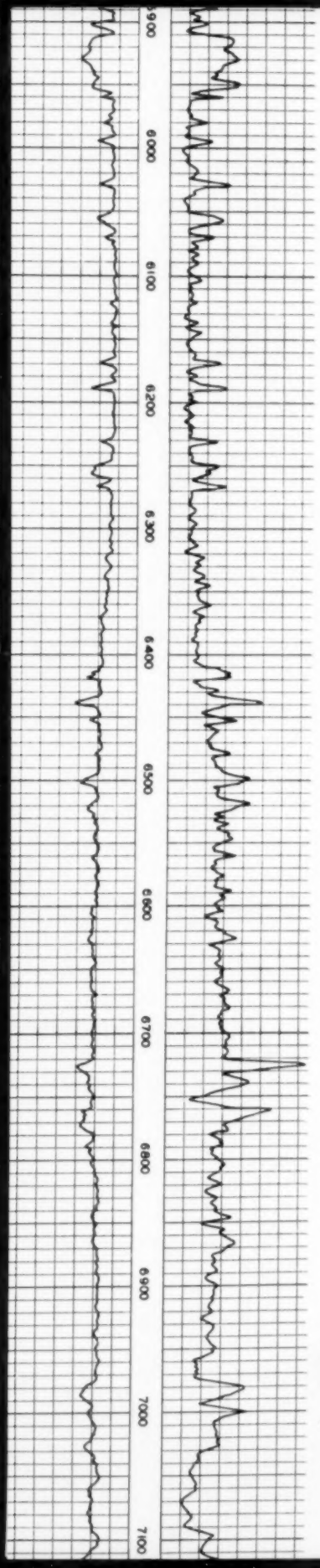

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Of Things To Come . . . In Oil

FUTURE OF OIL COMPANIES WITH LIMITED CAPITAL is in secondary recovery operations, claims W. H. Davidson, president of Tekoil Corporation. Davidson cites increasing negative odds against the wildcatter and high costs of offshore production as major factors. J. Wade Watkins, Bureau of Mines, has indicated that waterflooding alone is creating a new industry — water treating, with a future as "big and limitless" as the oil industry itself.

FOUR CORNERS AREA is the "future oil fighting ground," claims the Rocky Mountain operators. Most 1957 predictions call for drilling of 400 test wells in Southeast Utah, Southwest Colorado, and Northwest New Mexico. Manager of Skelly Oil Company's land department, D. N. Hill, forecast that the Four Corners area may become the nation's largest oil and gas field, based on current drilling successes and recent surface and geophysical surveys.

DOMESTIC CRUDE OIL NEEDS will never return to normal, say many government officials. Senator Dirksen of Illinois says American oil producers must supply a portion of Europe's oil for many months to come. Arthur Flemming believes the demand for U. S. oil will continue high indefinitely. This prediction cites the use of Latin American crude to fill European needs, eliminating most Venezuelan imports to this country. Either solution places the U. S. oil producer in its most favorable position in several years.

IT WON'T BE AS DARK BELOW THE ROTARY TABLE in the future if the promises of new methods of logging are fulfilled. Several companies are testing logging methods that have come after years of experimental work. One of the methods uses the bit as an electrode and records as the bit penetrates. Another method is aimed at recording sands that until now have resisted conventional logging techniques. In certain fields and under certain conditions oil or gas sands will show no break on the resistivity curve, but the new method shows great promise in picking up such sands. In fact, the new method, run experimentally on 20 wells, has been credited with at least one oil sand discovery.

OFFSHORE DRILLING CONTRACTORS may soon find the situation tightening up in the Gulf this year or early next year. Some operators feel the number of rigs may be reaching the saturation point, and it is likely that competitive bidding on offshore wells rather than through negotiations or long term contracts may come sooner than expected. Last count revealed 151 rigs active in waters off the Texas and Louisiana coasts.

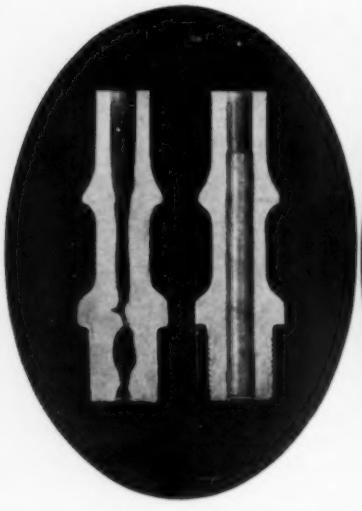
FUTURE OFFSHORE OPERATIONS look almost fantastic when taking a glance at what some operators have on the drawing board and are currently investigating. Automatic production controls will reach their ultimate due to economic justification offshore. Huge floating rigs for drilling in water over 150 ft are on the drawing boards; submerged tankage, networks of microwave systems for communications and controls; smaller structures, ocean bottom completions, etc., represent remarkable advances in thinking and planning.

AXELSON

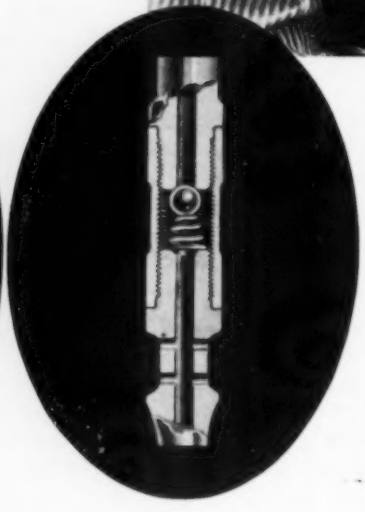
OPERATORS CONTROL CORROSION AND PARAFFIN WITH HOL-O-RODS

Close control of corrosion and paraffin conditions 'way down below is being practiced by the two operators on this page, with the help of Axelson HOL-O-RODS.
At left, Carter Oil Company Production Foreman Bill Dancy is supervising the running in of 1" HOL-O-RODS at J. Detrich #8, Trapp Pool, Kansas. Damage to equipment caused by troublesome conditions is substantially reduced by injecting corrosion inhibitor 2100 feet down through these hollow sucker rods into the reservoir. The same HOL-O-ROD installation is being used at the nearby J. Detrich #5.

PARAFFIN CUTTING. Injection of a paraffin solvent through Axelson HOL-O-RODS is being discussed by (l. to r.) Jim McKenzie, Axelson representative; Ernie Brant, Axelson District Manager; and Marlin Archer, pumper for Carl I. Olsen, producer. Located at Lake Houston, Texas, this well (State Lease Taylor #1) is using an Axelson plunger pump set at 5000 feet, and a complete string of Axelson HOL-O-RODS.



FIRST ONE-PIECE NON-WELDED hollow sucker rod in the field is the Axelson HOL-O-ROD, pictured above in two stages of manufacture. To avoid breakage resulting from the common practice of fabricating rod ends separately and then welding the ends to the rods, Axelson works the rods all in one piece, upsetting the ends, as shown in the left cross-section, and then re-drilling the hollow portion.



CHECK VALVE to prevent the back flow of well crude through HOL-O-RODS can easily be installed at the lower end of a rod string by using a standard coupling with a spring-loaded ball and seat, as shown in above cutaway drawing. Beyond this check, the injected fluid is ported to the annulus through drilled holes in a HOL-O-ROD Pony Rod. Axelson representatives can supply details.

AXELSON HOL-O-RODS were developed for use in hot oil treatment of oil wells to control paraffin, for chemical injection in corrosion control, for diluent injection to aid in the production of extremely viscous crudes, and for treating two-zone pumping wells.

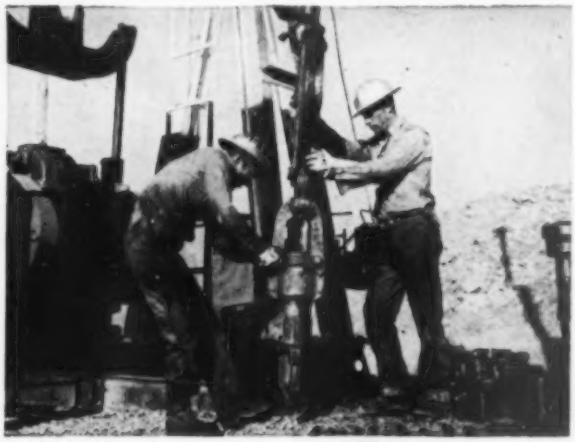
These applications have created another use for HOL-O-RODS: a means of determining bottomhole pressures by application of pressure bombs directly at the surface of the well. Still other uses are constantly being found by men in direct contact with producing problems.

PICTORIAL

QUICK FRAC. Shown supervising their first "River Frac" in Osage County, Oklahoma, are two district production superintendents for National Associated Petroleum Company—Bud Shewmaker (standing) and Pete Clark Jr. (kneeling with cap). It took only 38 minutes to frac the formation at 2500 feet with 1562 bbls. of sand, water, and mud acid. An Axelson 2 x 1½ x 10' 2" Sure-Seal Pump with double Axloy valves and a 44" chrome-plated grooved plunger produces this well (Rodeo Anticline #5-6). These pumps are standard equipment for most wells in the Osage. The sucker rods at lower left are Axelson #60 ⅝".

OLD FRIENDS. On board the "Gulf Pride" at Caddo Lake, Louisiana, are two longtime friends: Cleon Worley, Axelson District Manager and Axelson employee of 32 years, and M. V. Daniels, Assistant Area Superintendent for Gulf Refining Company. Daniels has served Gulf for more than 27 years in this territory. In this time he has used virtually every kind of pump Axelson has ever made. His wells range in depth from 900 to 6300 feet, and hole conditions vary from "problem children to little angels."

"DO-IT-YOURSELF." The Texas Company's #11 at Black Mountain, Wyoming, was losing production. The Axelson Sure-Seal 2" bore Rod Pump (API, RWT type) was pulled and checked out O.K. The crew wanted to pull the tubing wet to check it for leaks, but didn't have a drop valve. They made one out of the Axelson cup hold-down, and it did the job. Pictured pulling the well are two members of Dick's Well Service out of Powell, Wyoming (l. to r.): Clark Rook and Joe Mosebar.



No. 10

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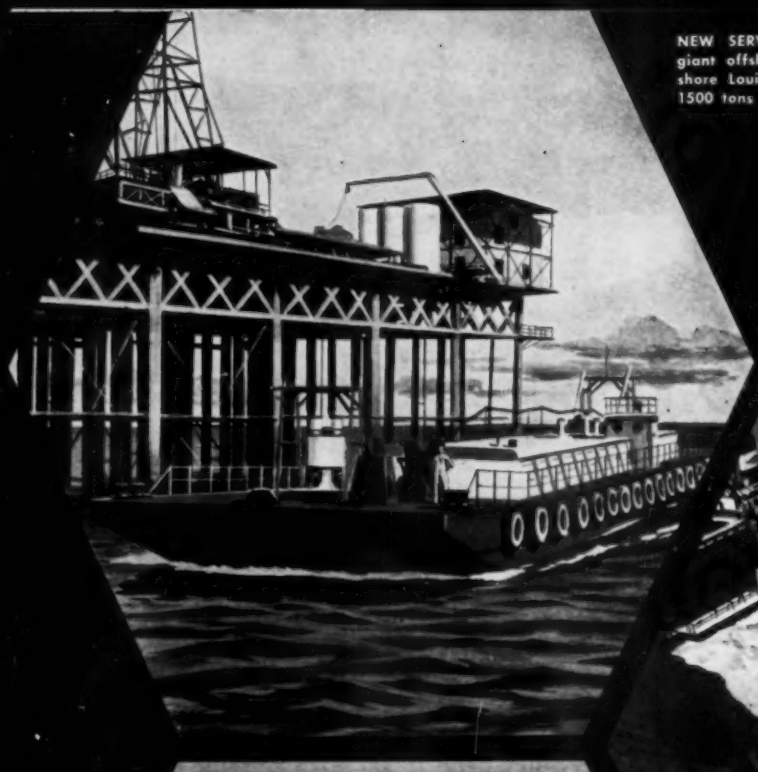
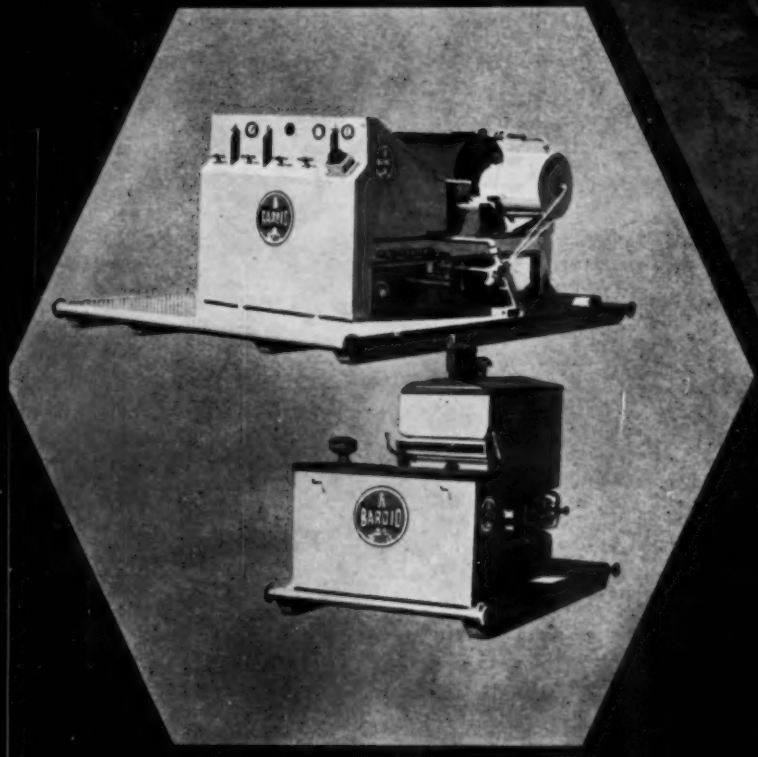


NEW SERVICES . . . such as the "Mr. George" giant offshore delivery vessel now serving offshore Louisiana Gulf Coast rigs. Carries up to 1500 tons of mud materials per load.

BAROID

NEW PLANTS . . . such as the new Marine Terminal and mill at New Orleans. Baroid has increased its stockpiles of products at all important points.



NEW EQUIPMENT . . . such as the BAROID MUD CENTRIFUGE for discarding drilled solids and reclaiming mud weight materials. More than pays for itself in mud savings and ease of mud control.

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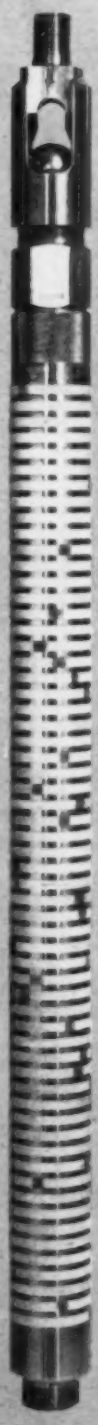
Metal to Metal Wear...

is the real villain in sucker rod pump troubles. It accounts for most of your repair and pump pulling expense.



The Martin Idea...

for getting away from this trouble has always been to make use of the best available materials — *Natural Rubber* for the key material in plunger rings; *Synthetic Rubber* for the key material in resilient ball guides for cages.

The accurately grooved and drilled metal body of **The Martin Plunger** does not touch the barrel. Only the resilient rubber and duck rings contact the barrel. This material — with its great natural resistance to abrasion as well as its slipperyness-when-wet — has a much slower wearing action on the barrel. Most often your barrel will not need replacing. These rings have an amazing ability to take the kind of abuse that goes with oil well pumping, and this means longer runs. Plunger cost is reduced because replacing the rings costs only about one fourth as much as a new plunger, and this saving is, of course, added to the barrel saving and longer runs.

Patent No. 2,591,174

The Martin Rubber Guide Cage protects the ball from all metal contact except when it rests upon its seat. The ball is protected to such an extent that ball and seat life is usually doubled. The synthetic ball guide and stop cannot beat out because of its resilience. Its life is therefore much greater than any metal and you get this longer cage life in addition to better ball and seat life. The two guides are easily replaced when the occasion does arise.

No real capital outlay is required to get these benefits because the cost of Martin Plungers and Martin Cages is very much the same as you are now spending for replacements — sometimes less.

All regular or stroke-thru ROD PUMPS and TUBING PUMPS can be equipped with Martin Plungers. Martin Rubber Guide Cages are made in all sizes and styles. Write for our catalog No. 4; also see Composite catalog for 1956-57.

JOHN N. MARTIN

Manufacturer

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CUTLER-HAMMER THREE-STAR OIL WELL PUMPING CONTROL is the overwhelming choice of oil field engineers everywhere. No other control is as rugged . . . Cutler-Hammer control is immune to blistering heat, to choking dust, to driving rain, sleet and snow. No other control is as dependable . . . Cutler-Hammer control, featuring vertical dust-safe contacts, can be relied upon to pump your wells *indefinitely* without attention as far as the electrical equipment is concerned. No other control is as completely automatic . . . the Cutler-Hammer Supertimer has made oil well pumping by *automation* a reality.

For your next pumping well, insist on Cutler-Hammer Three-Star Oil Well Pumping Control. No other control offers as many outstanding features: exclusive Cutler-Hammer Supertimer—Three-Star magnetic contactor with vertical dust-safe contacts—aluminized, chimney draft-design enclosure—vertical contact contactor type disconnect switch—advanced-design lightning arresters—full three-phase, three coil overload relay—selector switch for automatic or manual operation—dead phase protection—double door isolation of live parts—undervoltage release relay—spring-clip type fuse receiver—removable steel component base plate—padlock features for outer door, inner door, and Supertimer.

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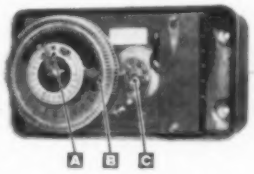

NEW CUTLER-HAMMER

Supertimer

This is automation in action. You pre-set the Supertimer to meet your field allowable and the control will do the rest, automatically. It starts, stops, restarts and cycles indefinitely, precisely according to your schedule. If a power outage occurs, any number of C-H controlled pumps are automatically restarted in an exact sequence to avoid overloading the power lines on inrush. Unfortunate coincidental starting of even two pumps is impossible.

- **A** Sets the precise restarting time delay from zero to 180 seconds. This is exclusive with the Supertimer—unfortunate coincidental starts of even two pumps are impossible.
- **B** Sets the daily pumping schedule—pull a tab for each fifteen minutes of pumping, space them through the daily 24 hour period as desired.
- **C** Sets the weekly pumping schedule—1, 2, 3, 4, 5, 6 or 7 days per week as desired.

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MOTOR CONTROL
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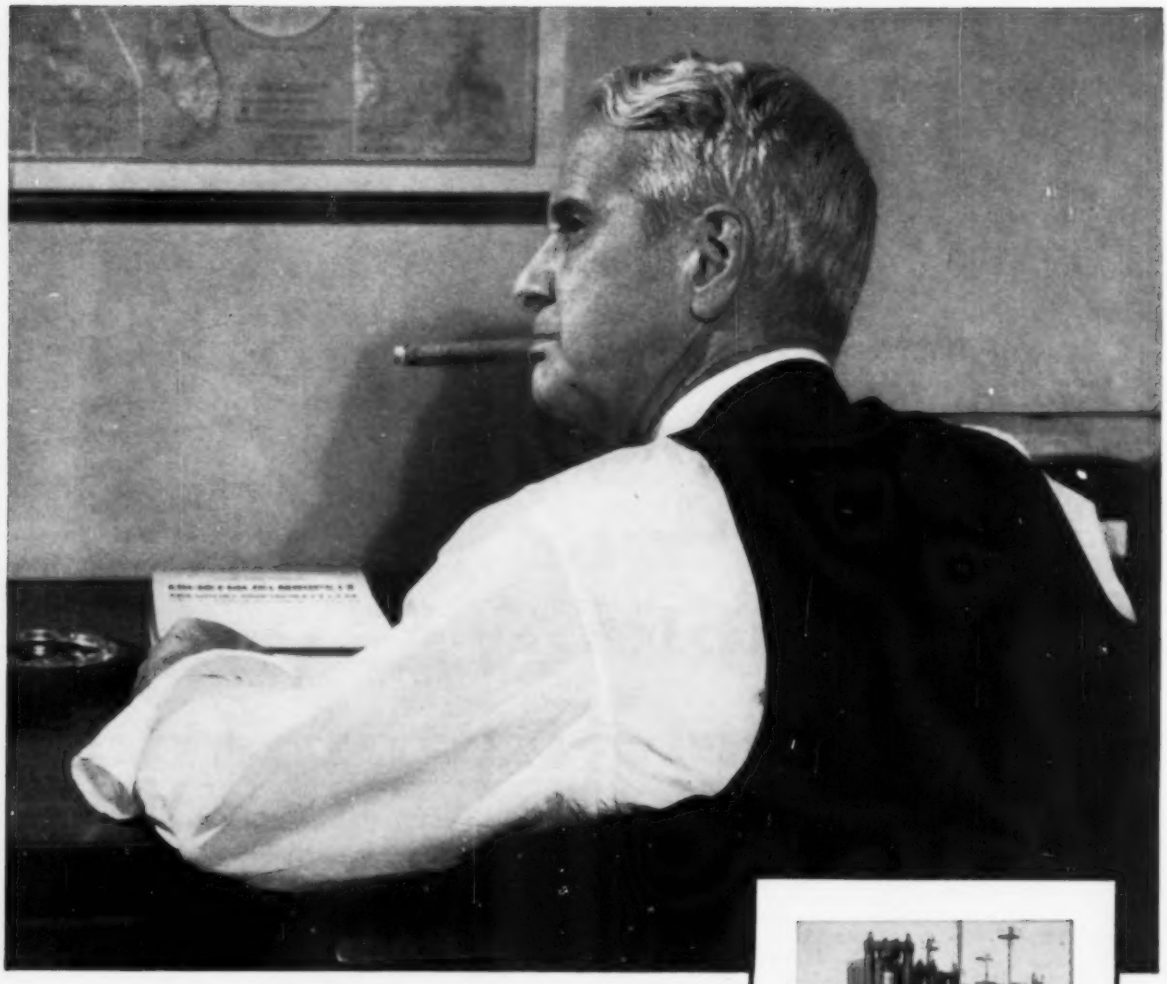
COMPLETE PROTECTION. The control is protected against lightning with exclusive, advanced-designed lightning arresters; and the three coil overload relay protects the pump motor from overloading and dangerous single phasing which often results from lightning.

CHIMNEY DRAFT VENTILATION. The heat-reflecting, aluminized enclosure insures a constant circulation of air . . . no nuisance tripping because of trapped heat.

DUST-SAFE CONTACTS. Dust-Safe vertical contacts stay clean and eliminate the necessity of contact replacement.



"And I say it has to be an ALDRICH PUMP!"

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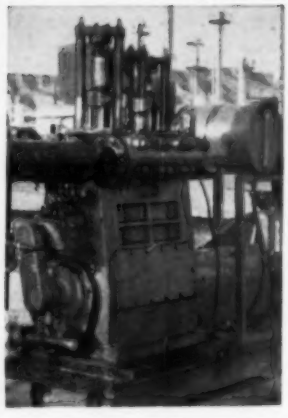
A copy of our new condensed catalog, showing the line of Aldrich Pumps is yours for the asking. Write for Data Sheet 100. The Aldrich Pump Company, 26 Pine Street, Allentown, Pa.



Shown above is one of a number of Aldrich 5" stroke, Triplex Pumps installed at a major west coast water injection project. These pumps are currently handling 35,000 bbl daily at injection pressures of 1,000 psi.

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No other tool offers the convenience, safety and utility of a GOT Circulating Valve. On a single run of a wire line tool, it is opened to permit straight or reverse circulation above a production packer . . . straight or reverse circulation above a standing valve . . . selective communication for any purpose, under any condition, at whatever depth it is installed. After the job is completed, only a single run of the wire line tool is required for closure. The whole job is fast, simple, safe; there's no need for equalizing pressures, no undesired communication, no blank plugs to install, no unnecessary trips with wire line tools.

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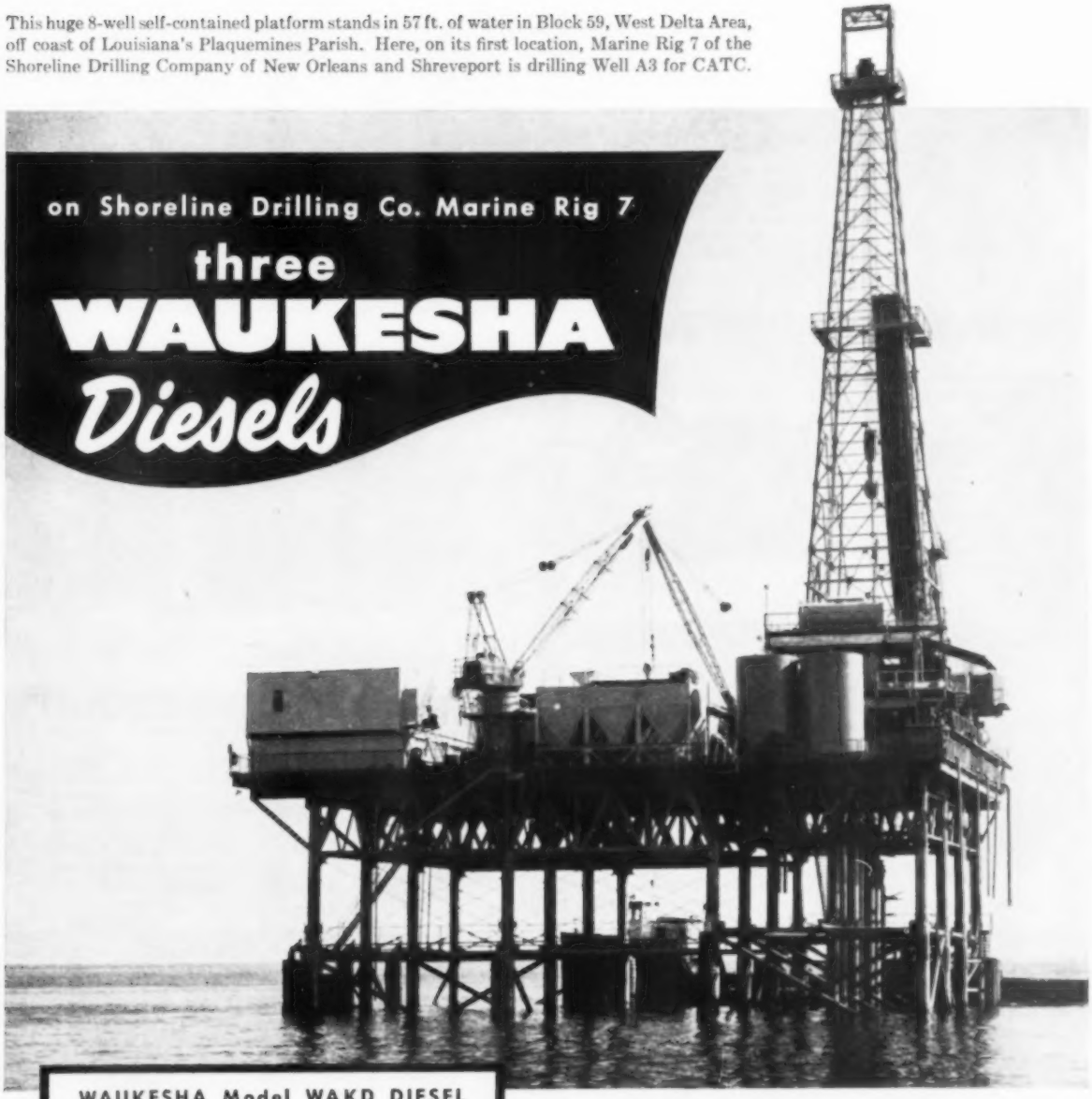
This huge 8-well self-contained platform stands in 57 ft. of water in Block 59, West Delta Area, off coast of Louisiana's Plaquemines Parish. Here, on its first location, Marine Rig 7 of the Shoreline Drilling Company of New Orleans and Shreveport is drilling Well A3 for CATC.

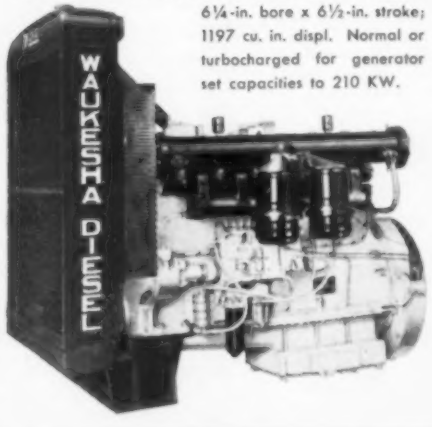


on Shoreline Drilling Co. Marine Rig 7

three WAUKESHA *Diesels*

WAUKESHA Model WAKD DIESEL

6¼-in. bore x 6½-in. stroke; 1197 cu. in. displ. Normal or turbocharged for generator set capacities to 210 KW.



337

each of the three 100 KW auxiliary power plants has its Waukesha WAKD Diesel

On Shoreline's Marine Rig 7 . . . a modern marvel of packaged efficiency . . . dependability is more important than ever. That's undoubtedly why Waukeshas were chosen for the auxiliary power plants. The power performance and rugged reliability of Waukesha Power has been repeatedly proved for every oil field need. Send for bulletins on Waukesha WAKD Diesel Series. *Waukesha Motor Company, Waukesha, Wis., New York, Tulsa, Los Angeles.*

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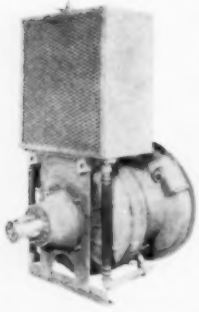


***Left.* 16,000 Series Three-Stage Torque Converter**

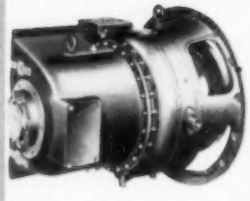
Will transmit up to 1000 hp at 1500 rpm. Seven specific torque ratings from 260 to 600 lb.-ft. SAE 00 flywheel housing size or clutch between flywheel and converter.

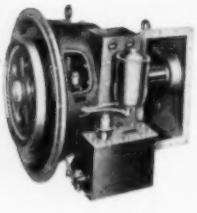
***Left.* 13,800 Series Three-Stage Torque Converter**

To 600 hp at 1800 rpm. Eight specific torque ratings from 230 to 540 lb.-ft. SAE 00 or 0 flywheel housing sizes. Spider drive or clutch between flywheel and converter. Output shaft takes full sidepull.

***Right.* 11,500 Series Three-Stage Torque Converter**

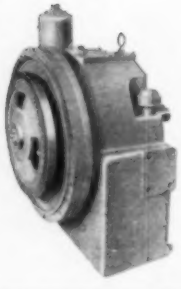
From 60 hp at 700 rpm to 425 hp at 2200 rpm. Six specific torque ratings from 230 to 450 lb.-ft. SAE 0 or 1 flywheel housing sizes. With or without clutch. Full range of input-output combinations available.





***Left.* 10,000 Series Three-Stage Torque Converter**

From 40 hp at 700 rpm to 335 hp at 2400 rpm. Eight specific torque ratings from 200 to 500 lb.-ft. SAE 1 flywheel housing size. With or without clutch. Full range of input-output combinations available.

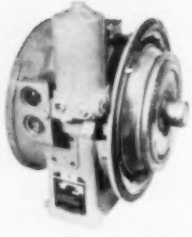


***Left.* 1500 Series Single-Stage Torque Converter**

From 30 hp at 1100 rpm to 207 hp at 2500 rpm. Five specific torque ratings from 165 to 330 lb.-ft. SAE 1 or 2 flywheel housing sizes. With or without clutch. Various input-output combinations available.

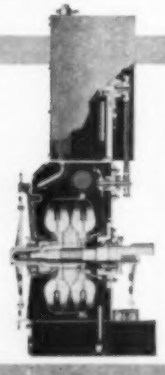
***Right.* 1300 Series Single-Stage Torque Converter**

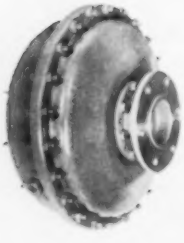
From 30 hp at 1450 rpm to 212 at 3200 rpm. Five specific torque ratings from 165 to 330 lb.-ft. SAE 2 flywheel housing size and SAE 2 or 3 output spacer housing. Output adaptable to Twin Disc SP-111 PTO.



***Right.* Disconnecting Fluid Power Take-Offs**

Model 27 HUD for engines to 850 hp at 1525 rpm. SAE 00 flywheel housing size. Model 21 HUD for engines to 580 hp at 1900 rpm. SAE 0 flywheel housing size. Both models equipped with radiator and fan and output shafts permit full sidepull.





***Left.* Fluid Couplings and PTO's**

Fluid Couplings from 7.4 to 27 inches, to 850 hp. Speeds to 5400 rpm. Fluid Power Take-Offs in 21, 17.5 and 14.5-inch sizes, to 500 hp. Speeds to 2700 rpm. SAE 0, 1 and 2 sizes. Ideal for high inertia loads and cushioning out shocks and damaging pulsations.

***Left.* HYDRO-SHEAVES®**

Combine fluid drive benefits with V-belt economy and convenience. For pumping jacks, shale shakers and many other oil field applications. Permit smaller motors, minimize equipment wear, reduce power factor. Fractional to 50 hp at nominal motor speeds.

Oil field equipment manufacturers, owners and operators look to Twin Disc for

biased

recommendations because . . .

Twin Disc — and *only* Twin Disc — offers a complete line of fluid and friction drives . . . three-stage and single-stage torque converters from 30 to 1000 hp . . . fluid couplings from fractional to 850 hp . . . friction clutches and power take-offs to 1050 hp.

Regardless of the oil field equipment or machinery application, you can depend upon Twin Disc products for the most efficient and profitable means of transmitting power.

For high-capacity mud pumps, rotary tables and drawworks, Twin Disc Three-Stage Torque Converters prove ideal. Providing up to 6:1 torque multiplication, the three-stage torque converter continually compensates for varying load conditions within a wide application range.

Where maximum torque multiplication is not required, Twin Disc Single-Stage Torque Converters, multiplying torque up to 3:1, are widely accepted in oil field applications. These units are excellent for transmitting power on shallow hole drilling jobs, oil field service equipment and other power installations where mild torque conversion is required.

Where torque multiplication is not necessary, oil field equipment can still benefit through the use of Twin Disc Fluid Couplings and Fluid Power Take-Offs. These permit full input torque to be transmitted at all times, regardless of load conditions. Like torque converters, their fluid connection dampens out harmful vibrations and shock loads, thus relieving equipment from stresses and strains that eventually result in downtime. The fluid's "slip" characteristic compensates for sudden overloads.

Twin Disc's line of friction clutches is built for all oil field equipment where friction drives lend themselves most profitably. These units are adaptable to air, hydraulic and manual operation, thus meeting the widest degree of oil field requirements.

Write to Twin Disc Clutch Company today or see your local Twin Disc Dealer . . . for unbiased recommendations on the type of drive best suited for your specific oil field equipment.

Twin Disc Clutch Company, Racine, Wisconsin; Hydraulic Division, Rockford, Illinois . . . with parts and service facilities throughout most of the world.

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WHAT USERS SAY
about Bucyrus-Erie Spudders

MICHIGAN, OPERATOR, 28-L: "Nicest rig I ever worked on . . . Bucyrus spudders really cut the hole and stand up well. They're easy to handle, too."

KANSAS, OPERATOR, 36-L: "Runs just fine . . . sure like those brake blocks. The 3-drum unit makes it simple to switch from baling, drilling, or running tube and rods. I also like the smooth running belt drive in place of noisy chain drive of competitive rigs."

ONTARIO, CANADA, CONTRACTOR, 60-L: "I like the 60-L's sturdy construction and easy operation. It's tops for this kind of drilling in sand and gravel surface where casing must be driven down almost 300 feet. It's easy to move, too."

OKLAHOMA, OWNER, 28-L: "We're very much pleased. This is the 26th well in 10 months continuous drilling, and the only repair expense has been $33 for two bearings."

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ILLINOIS, OWNER, 60-L: "In a more and more competitive business you can't make money and build a reputation with junk equipment . . . people get the wrong impression. The finest kind of modern machinery is the soundest investment a man can make."

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COLORADO, OWNER, 48-L: "Last word in drilling with cable tools."

These are actual quotes from users* of Bucyrus-Erie spudders on various drilling contracts throughout the country. In state after state, these experienced oil well contractors and operators say basically this: "We recognize the value of Bucyrus-Erie's close attention — during manufacture — to all the things that assure outstanding quality. The resultant fine performance, long-life construction, easy operation, mobility, and dependability of these spudders are the things that put the extra profits in our contracts."

Consider these quotes carefully. Then see your nearby distributor for the complete story on Bucyrus-Erie spudders. There's a size to fit your drilling needs.

*Names on request

31556

60-L 1,500-ft., top-to-bottom; 2,000-ft., servicing

28-L 2,500-ft., top-to-bottom; 3,000-ft., servicing

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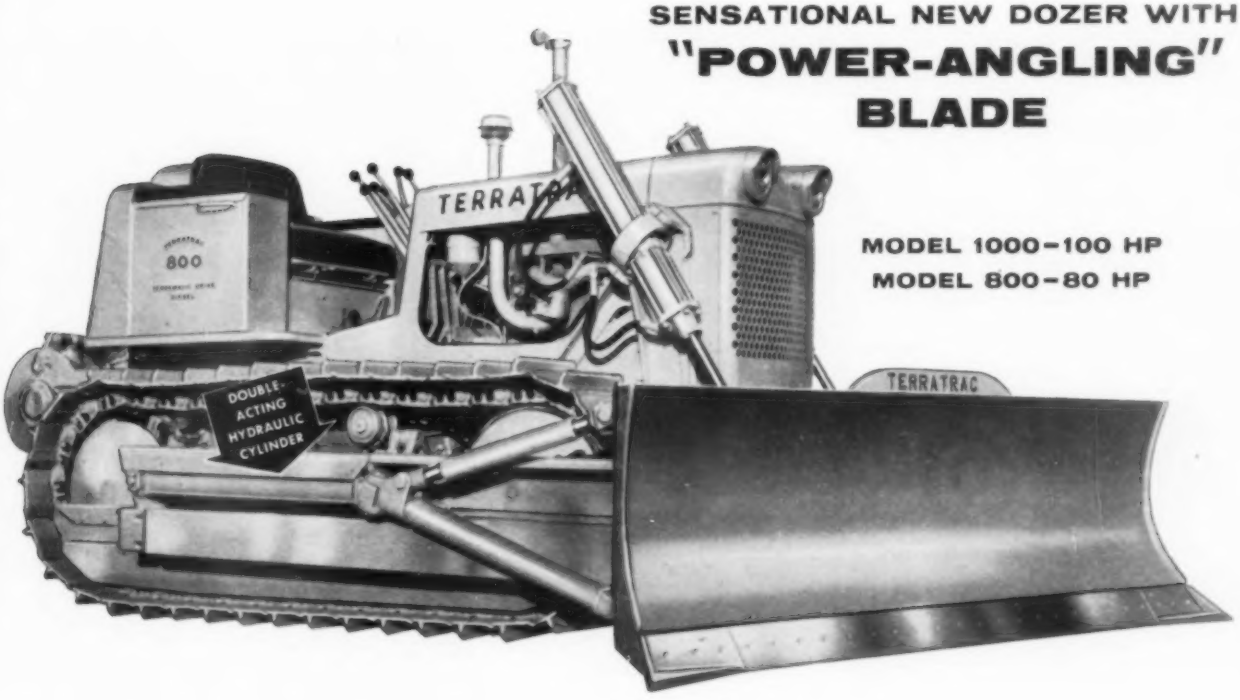
Another CASE Exclusive!

SENSATIONAL NEW DOZER WITH "POWER-ANGLING" BLADE



MODEL 1000–100 HP
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DOUBLES DOZER OUTPUT on grading, backfilling and windrowing jobs

You've wanted it for years . . . now here it is . . . a powerful, higher-speed angledozer that *angles hydraulically right from the driver's seat.* Enables operator to maintain blade in proper position for peak efficiency on all jobs . . . without wasting valuable working time on every blade-change.

New 80 and 100 HP Case-TerraTrac dozers also give you the extra advantages of power-boosting torque-converter drive, plus a new patent-applied-for *counter-rotating,* power-shift transmission that permits fast 360° power-turns within the track length of the machine. By changing blade angle "on-the-go", operator can thus keep pushing dirt in same horizontal direction on each pass, instead of backing-up *empty.* Or, he can peel off part of a pile . . . sweep it into the trench . . . and "counter-rotate" back into pile *within 3 seconds.* See these and other advanced features of the new Case-TerraTrac power-angling dozers *now* at your Case industrial dealer's, or —

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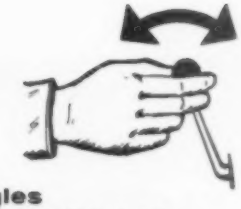
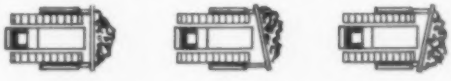
you just **MOVE A LEVER**



and blade angles **HYDRAULICALLY . . .**



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Rugged hydraulic scarifier or winch available as optional equipment on both 80 and 100 HP models.

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☐ 100 HP Model 1000 ☐ 80 HP Model 800

Name ..... Position .....

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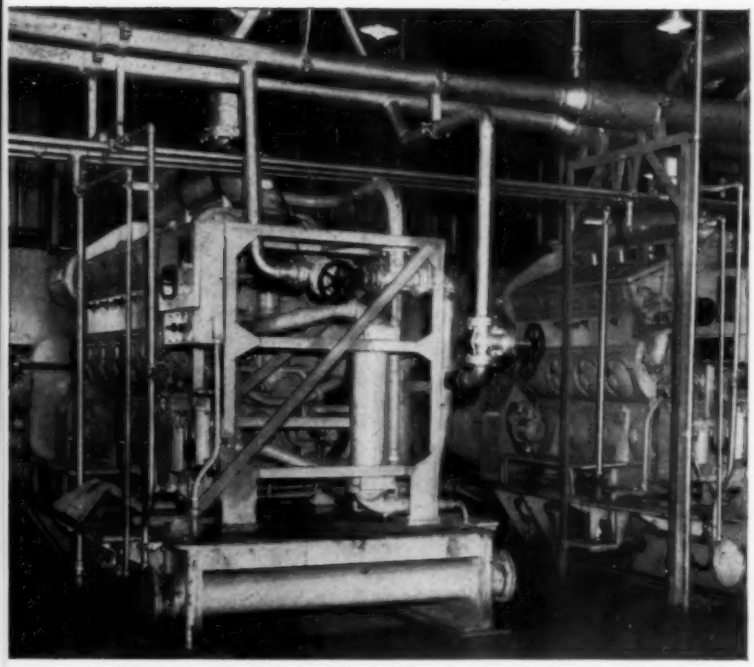
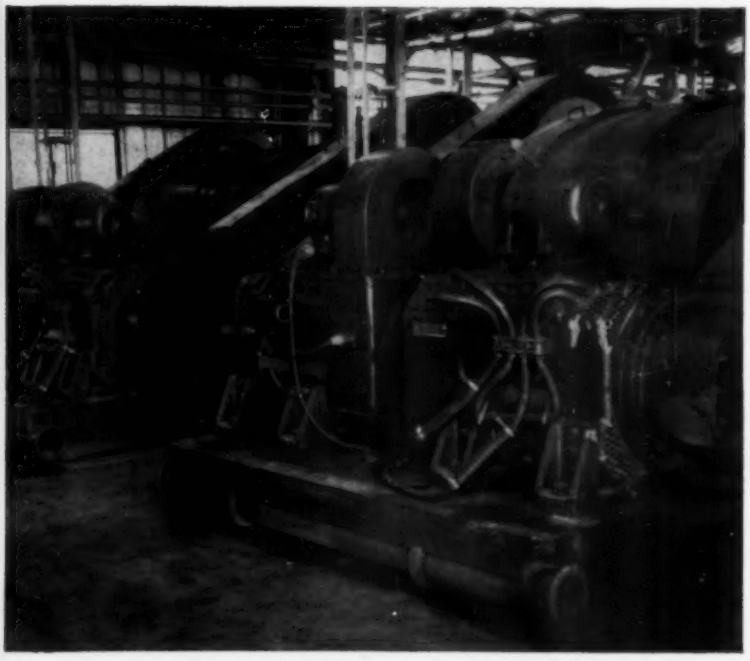
Industrial wheel and crawler tractors • dozers • loaders • backhoes • fork lifts

FIRST A TENDER — AND



Opposite the drilling platform on Rig 46 are three Electro-Motive 900-hp generating sets. Each of these 8-cylinder engines drives two 500-kw generators and comes complete on skids with air or water cooling, engine and generator controls. Kermac III, though radically different in design, uses the same standard Electro-Motive Power system.



Typical arrangement of Electro-Motive 625-hp dc drive motors with mud pumps is shown on Rig 46. Similar motors on the draw works are equipped with the new Super-Excitation control which provides a braking action when power is removed. In effect, the motor becomes a generator which slows smoothly and quickly yet retains all acceleration, torque characteristics and other power advantages of the series motor.

Towering mast on Rig 46 dwarfs men beside centrally-located driller's control that operates all Diesel-electric equipment. Called the tallest floating structure in the world, Rig 46 measures a whopping 268 feet from base to mast top. Sliding cantilevered drilling platform can drill six wells from one rig location. Overall area covered by the rig measures 242 by 202 feet.

NOW THE GIANTS

Pioneer Kermac fits new rigs 46 and 47 with ELECTRO-MOTIVE POWER

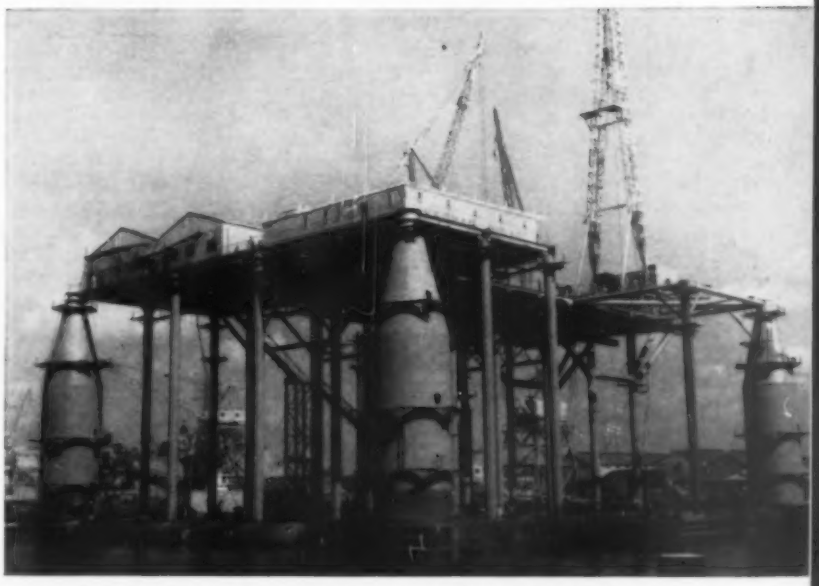
Kerr-McGee Oil Industries, Inc., was the first to operate a tender-platform with a complete Diesel-electric power system. The tender, Kermac III, working with Rig 48 in the West Delta Area has demonstrated its ability to make hole fast —recently drilled to 14,088 feet in 67 days.

Kermac III is powered by two Electro-Motive 900-hp generating units that team with a third on Rig 48 to power electric drive motors on draw works, rotary and mud pumps.

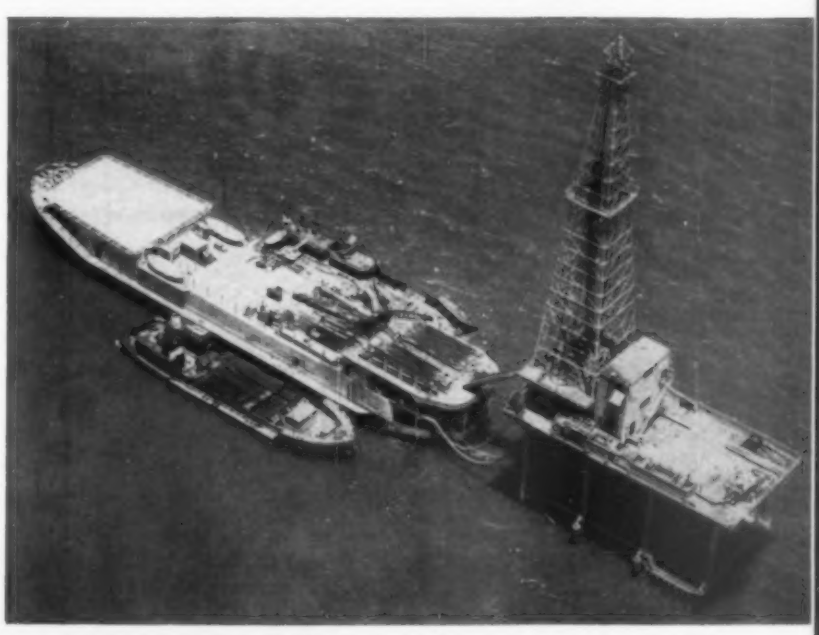
Kermac's new giants—Rigs 46 and 47—are of radically new design, yet their power is the same as that for Kermac III and Rig 48. The reason? Flexible electric cables between generating units and drive motors permit complete freedom of power arrangement. Thus, rigs can be designed to requirements without restrictions due to alignment.

Power to make hole fast; flexible to meet varying drilling conditions; simple, accurate controls; matched components, designed and built by one manufacturer—these are reasons why more offshore rigs use Electro-Motive Power than any other Diesel-electric drilling system.

Both land and offshore rigs are successfully reducing drilling time and costs with Electro-Motive Power. See or call your Electro-Motive representative for complete information.



Kermac Rig 46 is a new type of giant mobile barge capable of drilling in 70 feet of water. Rig 47, recently launched, is of identical design.



Kermac Tender III and Rig 48—first tender platform to have a complete Diesel-electric power system.

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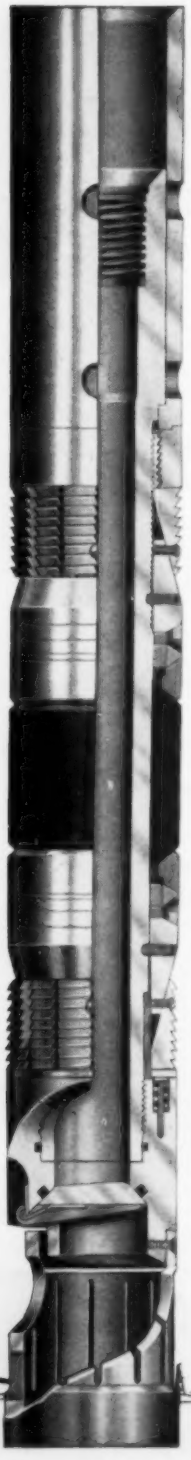
For Permanent-Type Well Completions

THE BAKER

RETAINER PRODUCTION PACKER

PRODUCT NO. 415D



BAKER PACKERS ADD PERMANENCE TO PERMANENT-TYPE WELL COMPLETIONS

When you select a Packer for a Permanent-Type Well Completion, remember this fact: of all the tools used in permanent-type well completions, only the *Packer* is required to be *permanent*. Guns, Extensions, Plugs, Gas-Lift and Circulating Valves can be removed or replaced on wire line . . . but the Packer, like the casing, is required to perform for the life of the selected producing intervals. Baker Packer Completions are Permanent Completions from the standpoint of packer performance.

Advantages of Baker Retainer Production Packer in Permanent-Type Well Completions:

PERMANENT, RELIABLE PACK-OFF will hold against any pressure differential from above or below that is safe for the casing.

FREE TUBING STRING . . . neither set-down tubing weight nor tubing tension required to achieve and maintain pack-off. Tubing can be anchored to Packer if desired.

CAN BE USED AS A SQUEEZE OR A PRODUCTION TOOL.

MEETS PERMANENT-TYPE WELL COMPLETION DIMENSIONAL REQUIREMENTS.

CAN BE SET ON WIRE LINE. PERMITS EASY REMOVAL OF TUBING STRING.

READILY DRILLABLE IN CASE OF EMERGENCY OR NEED.

BAKER OIL TOOLS, INC. HOUSTON • LOS ANGELES • NEW YORK

How Low Solid Muds Can CUT DRILLING COSTS

Water and oil emulsions can increase penetration rates, decrease the number of bits and round trips on a hole. The result is an overall savings in drilling costs

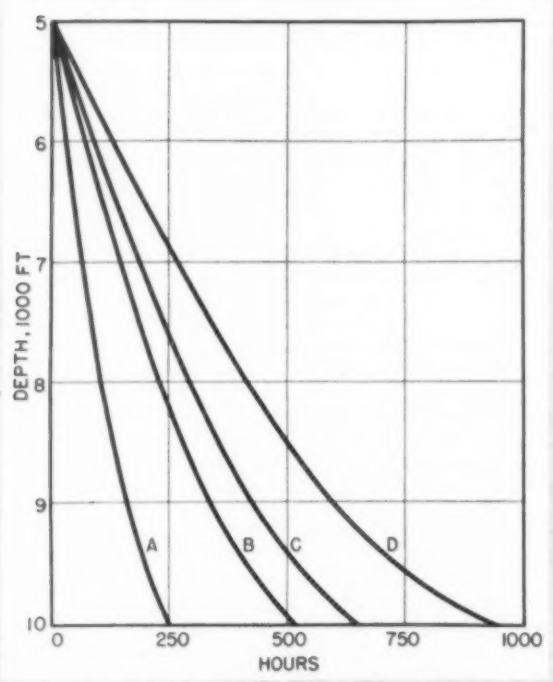
H. E. Mallory, *Great Western Drilling Company, Midland, Texas*

SOLIDS content of drilling muds has long been suspected as the retarding factor in penetration rates. As far back as 1953, Nick Wheless[1] of Wheless Drilling Company wrote, *"It is the solids content of the mud, not necessarily its weight, viscosity, and water loss characteristics, that affects the penetration rate."*

The AAODC recently sponsored a research project by the Battelle Institute to determine the effect of various types of drilling muds on penetration rates. One of the conclusions from this research was, *"Clearing cuttings from bottom of the hole speeds the penetration rate by giving the drill bit an unobstructed path. Various fluids show different effectiveness in clearing chips. Fluids of low viscosity, such as water, are much more effective than viscous fluids such as bentonite mud."* In addition to retarding the penetration rate, an excessive accumulation of solids contributes to the lost circulation problem.

Another author[2] states: *"Lost Circulation—Blowouts. . . . In areas where lost circulation is a problem, it has been extremely important to maintain a minimum concentration of low specific gravity solids. As this concentration increases and the system becomes less fluid, the resistance to normal circulation in the hole increases and results in increased back pressure on the formation. This high circulation pressure may be sufficient to break down the formation, and create a zone of lost circulation. The same high-solids condition also requires a slower movement of the drill pipe to reduce the downward pressure surges while running in the hole. Otherwise, chances of a formation breakdown would be aggravated. Moreover, a slower pipe movement is necessary while coming out of the hole containing a viscous drilling fluid. This is because upward pressure surges may momentarily reduce the mud hydrostatic head sufficiently to allow gas from an exposed formation to bleed into the well with each stand.*

FIG. 1.

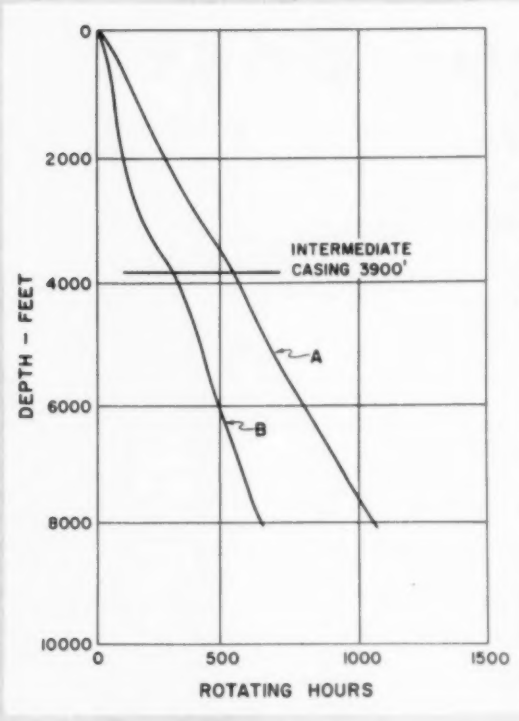


EFFECT OF DRILLING FLUID ON HARD ROCK DRILLING

PERMIAN BASIN
5000 - 10000 FT

	A	B	C	D
DRILLING FLUID	GAS AIR	WATER & OIL EMUL	WATER	GEL MUD
TRIP & ROTATING HOURS	250	520	650	940
BITS USED	12	39	58	82

COMPARISON OF DRILLING OFFSET WELLS WITH CONVENTIONAL AND LOW SOLIDS MUD



Drilling to depth of intermediate casing

	Well "A" Salt-Starch-Mud	Well "B" Flocculated Salt Mud
Feet Drilled	3870	4095
Number Bits (17½")	22	15
Rotating & Trip Hours	550	339
Mud Viscosity	39 to 45 sec	31 to 33 sec
Water Loss	15 to 20 cc	30 cc

(Well "A" used saturated salt water mud weighing 10.7 to 11.2 per gal. Well "B" used a flocculant in the saturated salt water. This flocculant can be used with or without starch or oil.)

Drilling below intermediate string to total depth of 8078 ft.

	Well "A" Gel and Chemicals Mud	Well "B" Water-Oil Emulsifier Pure CMC 5 to 7% Oil
Feet Drilled	4190	3983
No. Bits (12¼")	62	20
Trip & Rotating Hours	650	282
Weight of Mud	9.0 to 9.2 lb	8.3 to 8.6 lb
Viscosity	35 to 55 sec	31 to 33 sec
Water Loss	5 to 20 cc	6 to 30 cc

FIG. 2.

If enough gas is allowed to bleed in by this manner, it is possible that a blowout condition could result.

"Initiating circulation with the mud pump becomes more of a problem as the concentration of solids is increased. The higher this concentration, the slower the mud circulation must be resumed in order to reduce the chances for a formation breakdown. The higher the solids concentration, the less rapidly gas will work out of the mud system."

In hard-rock drilling field experience has shown that penetration rates are faster with clean fresh water. Many times even the addition of small amounts of bentonite to provide a "sample" mud has resulted in a noticeable decrease in penetration rate. The type of drilling fluid has a direct bearing on the rate of penetration and instructions to mud up, whether for samples or due to real or imaginary hole trouble, have caused many contractors sleepless nights. Fig. 1 shows the penetration expected in hard rock drilling, employing various types of drilling fluids. To achieve maximum benefits, there must be a planned drilling program, agreed upon by the contractor, operator, and geologist, and utilizing the services of the mud company's engineer.

How Solids Content Is Controlled

In an endeavor to provide the contractor with a better drilling fluid, drilling and mud engineers have devised several methods of controlling the solids content of drilling muds, with numerous advantages over the previously used gel-chemical muds.

Aerated mud. One of the newer concepts in low solids drilling mud is the use of aerated mud. By adding air to the mud, weights can be varied from the weight of air to the weight of mud. These weights will range from nearly zero to 8.4 lb per gal. In this type operation a mixture of air and mud equal to a mud weight of 3 to 5 lb per gal is used. Such a drilling fluid reduces the pressure on bottom and is more effective in removing cuttings. When pumped through the proper sized bit nozzles, penetration rates increase as much as 100 percent. It is obvious that this light weight mixture might provide great advantages in lost circulation areas.

Centrifuges. Another recent development to control solids is the use of cyclones and centrifuges. On the Gulf Coast where high weighted muds are commonly used, these machines are used to return the barite to the mud system. This has proved to be very economical and results in a big saving of weighting material. One item of interest which was discovered by using the centrifuge was the increase in penetration rate that was experienced by removing the undesirable clay solids. At the present time, the cyclone is being used on quite a few wells in West Texas to eliminate the sand and drilled solids from the drilling mud.

Flocculents. One method of dealing with solids in West Texas is to use flocculents in drilling the red beds. The flocculent is generally used in the salt water muds to flocculate the drilled solids and cause them to settle. Usually the mud is circulated through the reserve pits, thus allowing more time for these flocculated solids to settle. The theory of using drilling muds with minimum amounts of clay or shale solids has resulted in several distinctive muds, one being a simple emulsion of oil in water.

This type drilling fluid is being used in the upper part of the hole where it has been customary to drill with clear water. This fluid drills practically as fast as water, uses fewer bits, gets good cutting samples for the geologist, and can be used in many instances as is, for testing.

These benefits are very real when it is remembered that water gets unsatisfactory samples and is not generally trusted

for drill stem testing. The emulsion is made by adding 4 to 8 percent oil and a special emulsifier to clear water. Usually a very small amount of high viscosity pure grade CMC (carboxy-methyl-cellulose) is added. This mud stays free of clay and shale solids and cleans the hole well. Bits used in this emulsion have very few bearing failures. See Fig. 1 and 2.

Past experience shows it is possible to drill deeper with this emulsion than with clear water. When it becomes necessary to "mud up" or raise the viscosity, this is easily accomplished by the addition of approximately ½ to ¾ lb per bbl of high viscosity pure CMC and a few sacks of bentonite.

In the lower viscosity ranges, 40 to 50 sec API, no dispersant chemicals are needed. In viscosity ranges above 60 sec, it may be necessary to add small amounts of caustic soda and tannin or lignite. Usually water to control weight and bentonite and pure CMC for water loss and viscosity control are all the materials that are used.

An example of the increase in penetration which has been experienced by using low solids muds, both in the saturated and fresh water systems, is shown in the comparative drilling time curve of Fig. 2. Intermediate casing was set at approximately 3900 ft and a comparison of drilling time for this section of the hole using salt water mud is shown in the illustration.

Fig. 3 is a drilling curve showing comparative penetration rates between two offset wells in Gaines County, Texas. A comparison is also shown of some of the mud properties. The mud engineer on Well "A" checked only the weight, viscosity, and water loss. However, the weight is a measure of the solids content to a degree. It is noted that the weight of the mud on Well "B" was substantially less than on Well "A."

CMC mud. Another type of low solids mud being used extensively is the "Low Solids CMC mud." This mud is compounded by subsituting a small amount of Pure CMC for a large amount of bentonite, thereby securing the needed viscosity from the synthetic colloid instead of a large mass of clays. It can be used with or without oil. This mud was recently introduced in the San Juan Basin area and in addition to the increase in penetration rate the lost circulation hazards were minimized.

Low gravity solids are kept to a minimum by substituting a small concentration of high purity CMC (1 lb per bbl) for a large concentration of bentonite (15 lb per bbl). Too, these muds remain fluid after setting in the hole for long periods of time. While gel-chemical muds may have surface characteristics of zero-zero gel, many times these muds will have a "progressive" gel strength in that they tend to gel in the hole after trips, necessitating increased pump pressures to break circulation.

CASE HISTORY: Solution to Farmington Area Problem

Much has been said about the pressure surges caused by running the pipe in the hole at a rapid speed. It was our hope that by using low solids mud and employing better drilling practices, these surges would be reduced, thus aiding in the control of the lost circulation problem in the Farmington area.

It was planned to mud up after drilling the Ojo Alamo sand at approximately 2600 ft. However, while drilling with native mud the drill pipe became stuck at 1111 ft. After spotting oil and freeing the pipe, it was decided to mud up on the next bit to guard against recurrence of this problem. At 1831 ft, while on the "Bank" after coming out of the hole, the steel pits were completely cleaned and refilled with 300 bbl of clean fresh water and mud up operations were commenced.

Three hundred pounds of soda ash were added to the water to reduce the calcium content. Ten sacks of bentonite, 300 lb of CMC and 40 bbl of oil were added over a two-hour mixing period. A chemical barrel was rigged up and tied into the pump suction. Oil was gravitated into the barrel and then into the pump suction in a steady 1½-in. stream. Five sacks (250 lb) of high purity CMC were put into the system by blending it into the chemical barrel along with the oil. CMC does not yield in the oil but its contact with the water while going

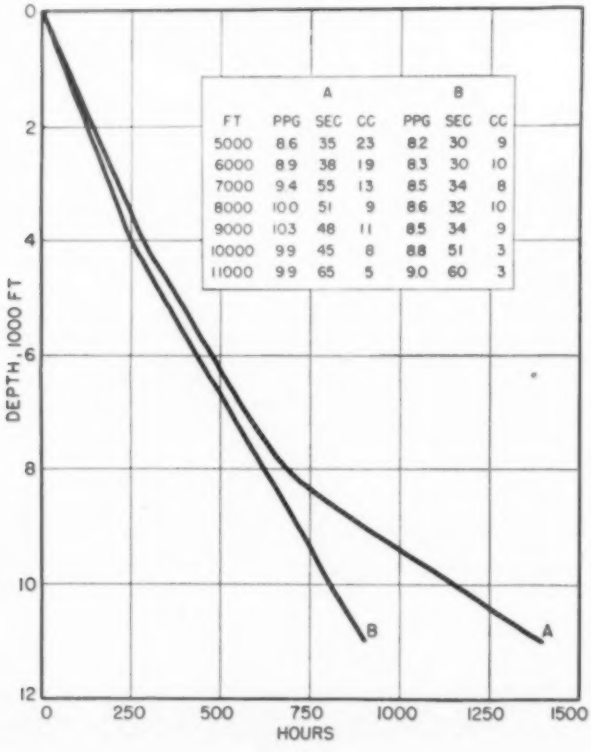
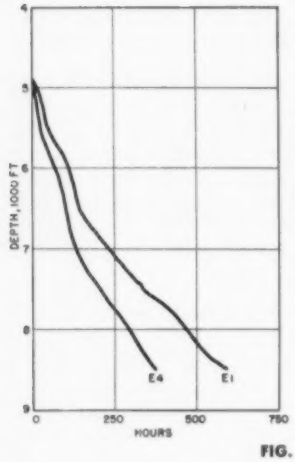


FIG. 3.

COMPARISON OF WELLS DRILLED
GAINES COUNTY
TEXAS

WELL	A	B
INTERVAL	0-11000	0-11000
TRIP & ROTATING HOURS	1380	907
BITS USED	109	84
COST PER FOOT	7.10	4.90
DRILLING FLUID	SALTWATER & STARCH 5000 CAUS-QUE BENTONITE 11000	SALTWATER STARCH & FLOC 5000 WATER & OIL EMUL 11000



COMPARISON OF WELLS DRILLED ANDREWS COUNTY TEXAS

WELL	E1	E2	E3	E4
INTERVAL	4900 6547	4900 6516	4900 6518	4900 6550
TRIP & ROTATING HOURS	596	448	381	375
BITS USED	36	23	23	19
COST PER FOOT	9.06	7.61	6.25	6.17
WEIGHT ON BIT	30-45	35-70	40-70	40-70
DRILLING FLUID	WATER 6300 MUD 6547	WATER & OIL EMUL.	WATER & OIL EMUL.	WATER & OIL EMUL.

FIG. 4.

through the pump, along with the agitation brought about by the mud guns, was sufficient to make it yield. Bentonite was added through a conventional hopper using a small auxiliary pump. There was no breaking out of the oil and no other emulsifying agent was used.

After the above mentioned materials had been added and approximately 30 min of vigorous gunning, the mud was completely mixed and had a viscosity of 50 to 55 sec. The bit was run to bottom and the mud in the hole allowed to escape over the shale shaker into the reserve pit. An additional 100 bbl of water were then added to the system to rebuild volume. After several circulations the mud had the following characteristics:

Weight	8.5	lb per gal
Funnel viscosity	42	sec
Cps. viscosity	14	cp
Initial gel	0	gel
10 min gel	0	gel
Water loss	4.8	cc
Cake	1/32	in.
pH	9	
Calcium content	280	ppm
Salt content	250	ppm
Sand content	0.4	percent
"P" alkalinity	1.2	
"M" alkalinity	1.9	
Oil content	10	percent

A volume of 440 bbl of mud was prepared at a cost of:

40 bbl of diesel oil at $7 per bbl	$280.00
300 lb CMC at $90 per CWT	270.00
10 sacks bentonite at $47.75 per ton	23.88
300 lb soda ash at $8.25 per CWT	24.75
	$598.63
Cost per bbl	$ 1.36

Caustic soda and quebracho were used to maintain zero-zero gels, and bentonite and CMC were used to maintain viscosity and water loss control. Three to five sacks of gel to 50 lb of CMC was the ratio we desired to use.

At a depth of 4670 ft, after being on bottom drilling seven hours, circulation was lost. This indicated that the lost circulation was caused by weak formation rather than running in the hole too fast with the drill pipe. Twelve pounds per barrel of lost circulation material (hulls and fibrous material) are added to the mud and circulation was re-established. Approximately one-half the volume of the mud was lost.

As soon as circulation was regained, it was decided to come out of the hole to change bits. A conventional bit was run in the hole at a reduced rate of speed. On subsequent trips, pipe was run in the hole no faster than 20 sec per stand. No further lost circulation was experienced. Drilling was resumed until total depth of 5400 ft was reached. Logs and casing were run without incident.

Comparative bit performance data between this well and the nearest off-set which used a gel chemical mud are given below.

	Well "A" Gel-Chemical Mud	*Well "B" Low Solids Mud*
Footage drilled	4959	5064
No. bits	24	19
No. rotating hours	258	192
Avg ft per bit	206	266
Avg ft per rotating hour	19	26
% Increase in ft per bit	——	29%
% Increase in pent. rate	——	37%

Mud cost, including oil, was $3200 as compared to costs of $3300, $3400, $4900 and $6400, for mud on four offset wells of comparable depth. Not only was the mud bill less, but better mud characteristics were maintained.

Subsequent wells in the area have proven that low solids CMC muds are an aid in increasing penetration rates and extending bit life. Together with improved drilling practices, lost circulation problems are minimized.

In one field in Andrews County, West Texas, low solids muds have cut drilling costs from $9.06 per ft to $6.17. Comparative data showing this improvement are shown in Fig. 4. Low solids muds have been used throughout West Texas and New Mexico and in every instance where comparable data are available, a substantial increase in penetration rate has been noted.

ADVANTAGES OF LOW SOLIDS MUDS

For the contractor:

1. Increased penetration rates.
2. Decrease in the number of bits.
3. Reduced wear on the rig.
4. Fewer fishing jobs.

For the operator:

1. Lower overall mud costs.
2. Lost circulation problems minimized.
3. Faster drilling (on day rate).
4. Better completions.
5. Lower bids by contractors.
6. More stable mud (requiring less supervision).

Mud Costs — Cost of drilling mud is an important factor in oil well drilling. Mud costs of low solids fluids are generally lower than the old style gel-chemical muds. This is because the need for dispersants is materially reduced and the total number of days on mud are fewer. Also there are fewer instances of lost circulation.

In a few cases the low solids mud costs are a little higher. However, the savings gained by increased penetration rate are so great that any increase in mud costs is insignificant by comparison. Rate of penetration showed marked improvement in 1956 over the previous year, and was up 192 percent over the 1941 rate. Since 1953, wages have increased 16 percent; oil field machinery, 16 percent, and tubular goods, 25 percent .Yet, contract footage prices have been reduced approximately 23 percent. Low solids muds have played an important part in this achievement. ★ ★ ★

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"Mr. Arthur," Coral Drilling Company's $4 million answer to modern offshore drilling. Unit can drill in 70 ft of water and can go to 20,000 ft. Barge design is by Friede & Goldman, Inc., New Orleans.

"ODECO's "Margaret," bigger than a football field in overall dimensions, utilizes twin hull construction for stability. Large vertical stabilizing columns aid ballast when lowering. Normal drilling depth is 65 ft.

P 422.912

Offshore Fleet Grows as...

Two Mobile Drilling Giants Get Set For Action

Coral Drilling Company's "Mr. Arthur" and ODECO's "Margaret" are costliest and biggest units to go to sea

"I christen thee 'Mr. Arthur'," says Mrs. Arthur O. Wellman, sponsor, as she prepares to release the champagne bottle at ceremonies in Mobile, Alabama. From left to right are: Harold Teasdel, president, The California Company; A. O. Wellman, associate of Coral Drilling Company; John M. Griser, president of Alabama Dry Dock & Shipbuilding Company; Mrs. Wellman; Jerome Goldman, vice president of Friede & Goldman, Inc., designers; Ted Weiner, president of Coral Drilling Company; and Tom Weymouth, vice president, Coral Drilling Company.

Mobile, Alabama — Two significant events to the offshore oil effort took place within a week amid the Mardi Gras celebrations in Mobile, Alabama. Two giant mobile submersible drilling barges were dedicated for service at the Alabama Dry Dock and Shipbuilding Company. On Saturday, February 23, Coral Drilling Company of Fort Worth, Texas, christened its $4 million ultra streamlined mobile drilling unit "Mr. Arthur," and just six days later, Ocean Drilling and Exploration Company of New Orleans, Louisiana, held open house to celebrate completion of the biggest mobile drilling barge of them all, "Margaret," which is said to cost about $3 million. Both units are expected to be on location by mid-April, and will bring the mobile offshore drilling fleet to a total of 27 units. Six mobile giants are currently under construction and at least two units are already planned and announced. Coral's "Mr. Arthur" will go to work for The California Company and ODECO's "Margaret" will drill its first well for Shell Oil Company. Both units are destined for the Delta offshore area.

Designed to drill in water depths up to 70 ft offshore, "Mr. Arthur" is of the

Compact and powerful engine room of "Mr. Arthur" looking down the line of three diesel-electric sets that provide over 2500 hp. While very compact in design, all equipment is accessible.

"Margaret's" structural members that support the upper deck sections and tie the two submersible hulls together. Note stabilizing columns at left.

Coral Drilling Company's "Mr. Arthur"

self-stabilizing submersible type ideally suited for drilling in those locations where the bottom is covered with a thick layer of soft unconsolidated silt such as commonly found in the Delta offshore area. Barge section measures 180 ft long by 151 ft wide and 12 ft deep. All sides of the hull are sloped to prevent scouring action, with only a 3 ft vertical skirt at the bottom.

Incorporated in the aft end of the hull section is the drilling slot which measures 34 ft long by 32 ft wide. This unusual slot width is to provide adequate space to drill three wells from a single position by allowing the entire drilling rig substructure to move sideways. There are eight ram columns, four forward and four aft, 39 in. in diameter and 89 ft from top of hull deck to bottom of upper deck section. Two 60-in. OD access columns, one midway on the port side, the other midway on the starboard side, make it possible for crewmen to go below into the large room located in the submersible hull section. Starboard access tube is equipped with an electrically-powered elevator, while port access tube is for emergency uses only.

For ease in towing, a specially-designed tow wedge was hinged to the submersible hull. It can be tilted slightly for towing purposes, or can be positioned horizontally to help support the unit when submerged. Deck house sides are of plate aluminum as is much of the floor plating and stairways of the upper deck. Crew quarters, lounge, dining hall, guest room, offices and galley are air conditioned by two 15-ton capacity units. Accommodations are provided for 44 men. Two vapor-compression distillation units provide a total of 14,400 gal of fresh potable and drilling water per day.

"Mr. Arthur's" power plant. Barge's designers state that "Mr. Arthur" is among the first mobile offshore units whose drilling equipment is entirely diesel-electric driven, including all drilling and auxiliary equipment. Main power plant consists of three diesel engines driving direct current generators. Each engine is rated at 850 hp continuous with an engine speed range from 350 to 1000 rpm. They are equipped with water-cooled turbochargers, after coolers, air inlet silencers and filters, governors and speed changers, over speed trips and air starting motors. Rig is capable of complete operation from the main engine generators alone without reliance on any outside power source.

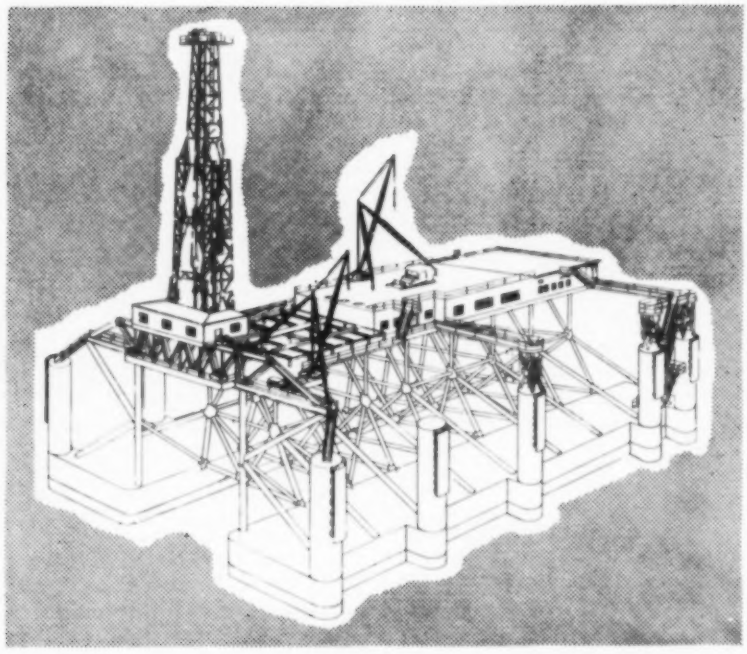
Electrical generating units. Each of the three engine-generator sets are equipped with two d-c generators, each rated at 550-kw at 1000 rpm. They are differential compound type designed to avoid use of external control components and also the use of speed increaser or decreaser gears. Voltage at no load is about 900 v; at rated output, 550 v; and at 1800 amps, approximately 50 v. Generator Set No. 1 has two 550-kw d-c generators; Generator Set No. 2 has two 550-kw d-c generators and one 300-kw, 450-v, 3-phase 60-cycle a-c generator; and Generator Set No. 3 has two 550-v d-c generators and one 300-kw, 450-v, 3-phase, 60-cycle, a-c generator. All three main engine generator sets are equipped with auxiliary 50-kw d-c generators, which are belt driven and mounted above the main generators.

Drive motors. Separately excited shunt field motors are the main driving power for all major rig components. Two of these traction type motors, each rated at 625-hp continuous, drive each of the two main mud pumps, thus providing a continuous rating of 1250 hp for each pump.

Two of these traction-type motors power the drawworks. Each d-c motor is rated at 685 hp, so that 1370 hp is available for drawworks power. These motors are capable of creeping in either direction for use in operating the cathead. All motors are equipped with closed circuit cooling systems, including water-to-air heat exchangers and separately driven blowers for operation in a gas contaminated atmosphere.

Drilling equipment. Drawworks has an input rating of 1500 hp, and is capable of drilling to 20,000 ft. It is equipped with a 60-in. hydraulic type brake. Drum is grooved for 1⅜-in. line, and the drawworks includes an automatic drilling control. There are two large main mud pumps, each with an input rating of 1000 hp in addition to an auxiliary pump.

The mast is of new design and is rated at 1,000,000-lb capacity. It is 142 ft high and rests on a 5 ft by 34 ft by 36 ft substructure that can be skidded



Completed ODECO unit will look like this isometric view of the "Margaret," showing the two hulls, truss members and upper deck sections.

sideways for drilling as many as three wells at one location.

Other drilling equipment includes a 27½-in. rotary table separately driven by a traction type d-c motor; equipped with automatic power slips; a 450-ton drilling hook with hydraulic snubber and positioner; a 500-ton traveling block; and 500-ton swivel, degasser unit, and dual all-galvanized shale shakers. Included for service is a complete logging unit mounted on the upper deck, and a self-driven cementing unit on the second deck.

The bulk mud system is composed of two parts. Located above the mud pits are three 1000-sack bins for dry bulk mud storage and two 1000-sack bins for bulk cement storage. Bulk material is fed into the mud pits or into the cement hopper by air slides. Located in the submersible hull is storage for 4000 sacks of dry bulk mud and 2500 sacks of cement. Bulk material may be transferred from the hull storage to the upper bulk bins, or from upper bins to hull storage by means of pneumatic conveyors.

Top of the crew quarters and engine room is the heliport. Facilities are also installed to accommodate crew boat landings as well as bumpers for larger service and supply craft.

ODECO's "Margaret"

Of all the 27 mobile drilling units in offshore operation along the Gulf, this will be the largest in terms of overall dimensions. Bigger than a football field, the "Margaret" will measure 300 ft long and 200 ft wide and can operate in 65 ft of water. These are the outside dimensions of the lower sections which are actually two hulls 300 ft long by 60 ft wide and separated by an 80-ft gap. Lower hulls are 12 ft deep. Upper deck, rising 93 ft above the hull bottoms and centered longitudinally, is 70 ft wide and 300 ft long. This upper section consists of two main decks centered over the open gap between the twin hulls. Stability in towing, raising and lowering is the purpose of the two hull construction. A network of 20 and 50-in. cross members tie both hull units together and support the upper section.

Stabilizing columns. Additional stability is provided by ten 15-ft diameter stabilizing columns which can be filled or evacuated by pumps. These columns located on the outboard side of each hull offer no structural support to the submersible unit. Large centrifugal pumps fill and empty these columns as needed to add stability when raising and lowering the barge to form part of the ballast system. It is also felt that the twin hull construction will offer less resistance in towing. However, overall massive size of the unit and concentration of weight in relation to geometry of the unit is expected to stabilize it in rough water when floating.

Power plant and rig drives. Giant diesel-electric power plant of the "Margaret" consists of reconditioned equipment purchased from the government and formerly used in marine service. The two main engines are rated at 1600-hp each. Electric motors driving the drawworks are reconditioned and are rated at 1600 hp each at 600 rpm. There are two such motors driving a common shaft which is connected by extra heavy duty chain to the jack shaft of the drawworks. The new 27½-in. rotary table is separately driven by a 500-hp electric motor. Each of two main mud pumps are driven by an 875-hp d-c electric motor.

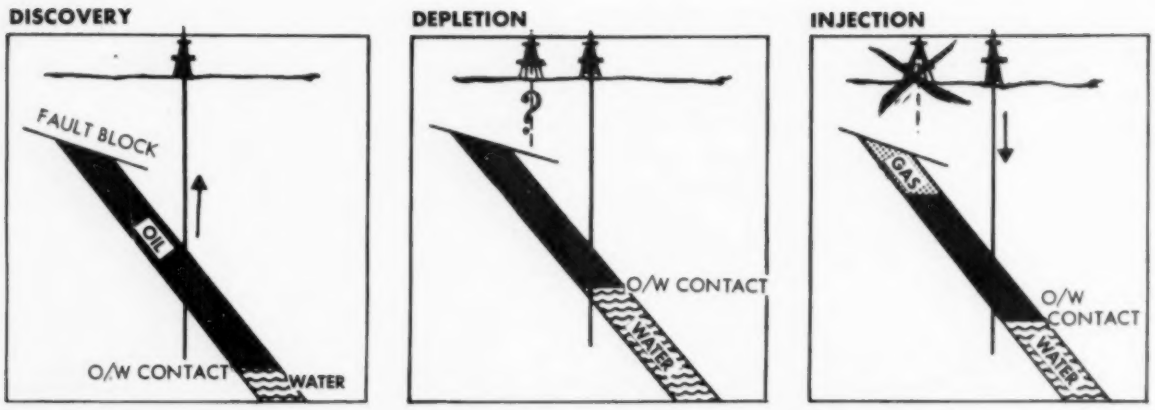
Storage facilities. On the engine deck are located mud pits to store 1000 bbl of active mud and 500 bbl of reserve mud. Sack storage is provided for about 5000 sacks of mud and bin storage for 2200 sacks of cement. In the submersible hulls is storage space for 3500 bbl of diesel fuel and 3500 bbl of fresh water. Although a waste heat evaporator can distill 1000 gal of sea water per hour, an additional storage of 1000 bbl of potable water is provided on the engine deck.

Drilling equipment. One of the latest and newest designed drawworks has been incorporated on the "Margaret." In a single package are concentrated the drawworks with built-in sand reel, two traction type electric motors and the auxiliary brake. All controls are located at the drillers position to provide four speeds to the main drum, two to the sand reel and one to the rotary. The drawworks has a recommended nominal input horsepower rating of 2500 hp, making it one of the most powerful rigs in the offshore fleet.

Portable derrick is of special design and has a nominal gross capacity of 1,125,000 lb. It is designed to withstand 125 mph winds and measures 142 ft high and has a base of 16 ft by 26 ft. Crown block consists of one 60-in. tandem fast line and seven 52-in. diameter forged rim sheaves mounted on 10-in. diameter shafts. The crown is so arranged that it can be shifted in 3-in. increments within a 2-ft diameter circle. Traveling block has a capacity of 500 tons, and swivel has a dead load capacity of 400 tons, with a 200 ton load capacity at 100 rpm. Each of two main mud pumps are rated at 1000-input-hp, with an 18-in. stroke and 7¾-in. maximum liner size.

Living quarters. Living quarters are air conditioned and include a large recreation room, dining hall, offices for tool pusher, engineer and guests. These quarters are on the main top deck, and the helicopter landing area is located on top of the crew quarters.

ODECO's fourth barge. The barge "Margaret" is the latest addition to Ocean Drilling and Exploration Company's growing offshore drilling barge fleet which now totals four. Previous units were "Mr. Charles," "John Hayward" and "St. Louis." ★ ★ ★



Well in dipping beds . . . develops high water-oil ratio. Drill another well? . . . Nope! Inject gas downdip to displace oil in "attic."

P 511.73

Production and bottom-hole pressures up, additional drilling development costs down . . .

Updip Oil Recovery By Downdip Gas Injection

Successful operation in West Hackberry field, Cameron Parish, Louisiana, suggests new applications in many anticlinal structures to eliminate sidetracking, more drilling

R. M. Morrow
Pan American Petroleum Corporation
(formerly Stanolind Oil and Gas Company)
New Orleans, Louisiana

DOWNDIP gas injection may be employed in oil reservoirs, subjected to an active water drive, to:

1. **Decrease or eliminate the expense of additional development and**
2. **Increase ultimate oil recovery by draining the updip region more effectively than wells drilled to accomplish natural depletion.**

In the case of downdip gas injection into the sharply dipped Camerina "B" sand in the West Hackberry field, Cameron Parish, Louisiana, both purposes were satisfied.

In five years of injection into this formation, dating from 1950 to 1955, oil injection has totaled approximately 1,000,000 bbl. In this time 3.15 billion cu ft of gas was injected in one well. Since that date gas has been similarly injected, using the same well, into the Camerina "D" sand, which has a very inactive water drive.

Recovery of updip oil by gas introduced at a downdip location is based on the premise that gas need not be injected at the crest of a structure to displace oil from the pinchout or "attic" region of a reservoir. Recovery or upstructure oil by downdip gas injection utilizes the gravitational forces that are operative in an oil producing formation to accomplish this displacement.

Gas injection operations may be conducted in several different ways and for various purposes. A common practice is to inject gas at the crest of the structure to create a gas cap or to augment a gas cap originally present in the reservoir. In some cases, the gas returned may be only the volume of gas produced with the oil. If an extraneous source of gas is available the injected volumes may be equal to all reservoir withdrawals. Regardless of the type of operation, most gas injection projects are designed principally to increase ultimate oil recovery and to maintain high producing rates by supplementing or replenishing reservoir energy.

Downdip gas injection to recover updip oil takes advantage of gravity segregation to obtain the benefits of crestal gas injection without assuming unnecessary drilling obligations.

Downdip gas injection also may be advantageously used in reservoirs controlled by a water drive as a means of stabilizing the water level and maintaining well utility. Application of this practice may be best illustrated by reviewing the history and conditions which led to the inception of a downdip gas injection project in the West Hackberry field. Although the field in question is a piercement type salt dome, the subsurface features are in certain

respects similar to conditions encountered in many faulted anticlinal structures.

Case History

Fig. 1 is a structure map of the Camerina "B" sand on the north flank of the field. Production on the north flank of the West Hackberry Dome was discovered in 1940; however, the Camerina "B" sand was the least important of the three major zones encountered. For the most part, early development of the "B" sand was accomplished by dually completing wells that had been drilled to zones of greater potential. The productive area of the Camerina "B" sand was ultimately defined as a continuous band, one-quarter of a mile wide and extending approximately two miles along the periphery of the dome. Original oil-water contact was estimated to be at minus 9600 ft.

Fig. 2 is a schematic cross section that depicts the general subsurface conditions that were found on the north flank of the West Hackberry Dome. It will be noted that the dip of the formations in this area approaches 60 deg. The program that had been followed in developing the Camerina sands led to the drilling of the majority of wells at mid-structure or downdip locations where sands were generally better developed. As a result, updip limits, which are thought to be sealed against a low angle peripheral fault, had not been clearly defined nor had the updip

Pumping well, one of the few, in West Hackberry. Most of the wells are still flowing, thanks to effective gas injection.

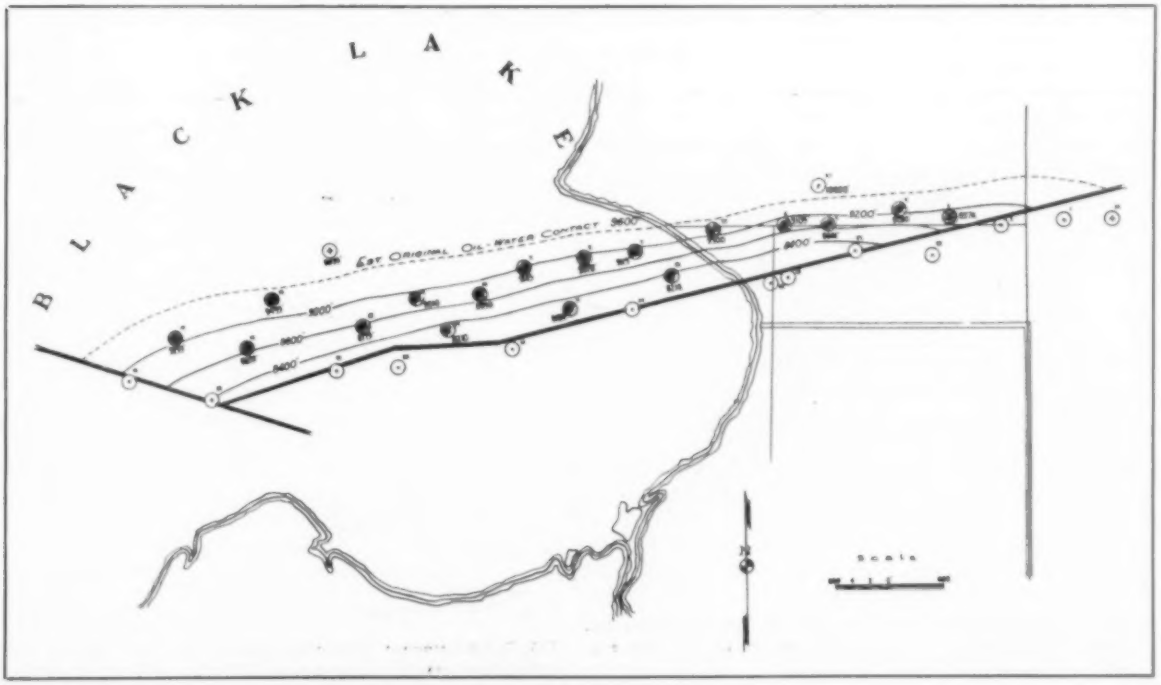


FIG. 1. **Structure map** of the Camerina "B" sand on the north flank of the West Hackberry Dome.

portion of the reservoirs been adequately developed. For example, of the 17 wells that had penetrated the Camerina "B" sand above the original oil-water contact, nine had topped the formation below 9000 ft and 14 had encountered the Camerina "B" zone below 8700 ft. Well bore locations have been projected along strike on this schematic section to demonstrate the relative position of wells drilled through the Camerina "B" sand.

Field Development Retarded

Physical characteristics of the Camerina "B" sand and the properties of oil in this reservoir have been tabulated below. The saturation pressure of 2970 psi was considerably below original reservoir pressure of 4150 psi measured at a datum of 9000 ft.

Physical Characters Camerina "B" Sand

Sand	
Porosity, percent	29.8
Permeability, millidarcies	1320
Interstitial water, percent	16
Fluid	
Gravity, API	30°
Saturation pressure, psi	2970
Original solution gas-oil ratio, cu ft per bbl	615
Reservoir volume factor	1.21

Because of the retarded development of the Camerina "B" sand, production from this reservoir from 1940 to 1943 was less than 500 bbl of oil per day. The performance history of the Camerina "B" reservoir (Fig. 3) indicates that the bottom-hole pressure remained at approximately 4100 psi over this period. In the latter part of 1943, additional completions were made and production from the Camerina "B" zone gradually increased to a peak of 2200 bbl of oil per day in the summer of 1944. The rapid pressure decline observed during this period dictated a reduction in producing rate to minimize the possibility of fluid channeling from the higher pressure Camerina "C" sand. Reservoir pressure stabilized between 3700 and 3800 psi at a producing rate of approximately 1400 bbl of oil per day. On the basis of reservoir performance data and material balance computations, it was concluded that the Camerina "B" sand was being controlled by a fairly active water drive. This observation was subsequently verified by the production of water from wells completed low on structure.

The Author

Richard M. Morrow is district engineer for Pan American Petroleum Corporation's (formerly Stanolind Oil and Gas Company's) New Orleans district. Prior to his present assignment, he was a senior petroleum engineer in the reserve and reservoir engineering section of Pan American's Texas-Louisiana Gulf Coast division office. A petroleum engineering graduate of the Ohio State University, he has been with Pan American since 1948.

Implications of a water drive in the Camerina "B" sand were, of course, obvious. With nine wells located below 9000 ft, it meant that over one-half of the available producing capacity would be lost after slightly more than one-third of the reserve had been recovered. It further signified that depletion by remaining wells would be extended over a considerable period of time with a resultant increase in operating expense. A third and equally important factor was the loss of oil located in the updip or "attic" portion of the sand above the highest wells that had penetrated the Camerina "B" zone. No wells had encountered the Camerina "B" formation above 8200 ft, although the pinchout was estimated to be above 7900 ft.

Several Programs Evaluated

To offset potential loss of producing capacity and to insure efficient recovery, various depletion programs were investigated. One such program considered sidetracking three existing wells and drilling seven new wells at locations as near the pinchout as possible to effect maximum recovery by natural methods. Water drive would then flush reservoir oil updip to these wells. There were, of course, limitations to this program among which was the uncertainty of the location of the pinchout zone. It was considered virtually impossible to locate the proposed wells so that all portions of the updip region could be adequately drained. A substantial amount of oil would still remain unrecovered above the row of new wells.

Another proposal which was advanced was to inject gas into the "B"

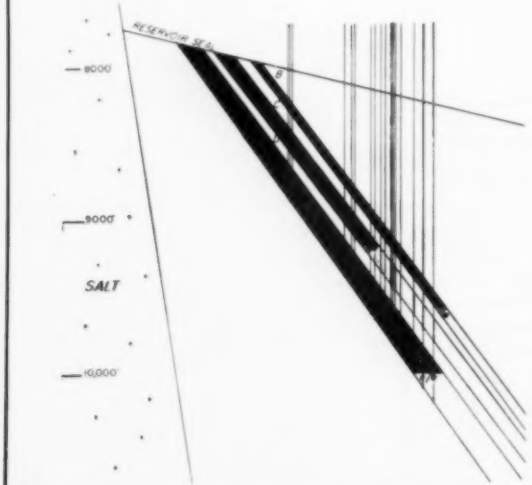


FIG. 2. **Camerina sands, "B," "C," and "D," have formation dips approaching 60 deg. Most of the wells were drilled mid-structure or lower.**

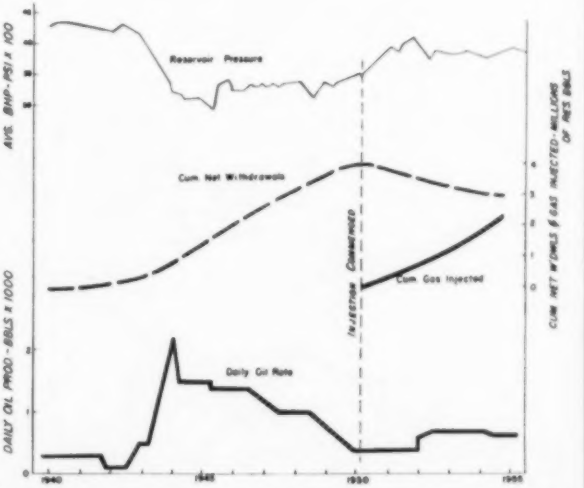


FIG. 3. **Performance history of Camerina "B" sand indicates that bottom-hole pressure leveled considerably above 3900 psi.**

West Hackberry field — a bird's eye view. Most of the field extends westward into Black Lake. Walkways in the lake connect wells and carry gathering lines to tank batteries.

sand through one of the existing wells. It was reasoned that the combination of steep dip and high permeability would allow injected gas to migrate updip into the most inaccessible reaches of the pinchout area and displace oil downdip to the producing wells. It was also postulated, but with less certainty, that injected gas would move laterally throughout the "attic" region of the reservoir and possibly establish a reasonably uniform gas front. Gravity segregation of oil and gas and expansion of artificially created gas cap by continued gas injection offered a means of effectively draining essentially all updip pore space whereas depletion by natural water drive mechanism would necessarily result in losing oil that remained trapped above the highest wells drilled. Pressure maintenance by gas injection also offered a means of stabilizing water level and preventing flood-out of downdip wells. A course of gas could be obtained by gathering casing-head gas that was being flared in the field. Conservation of this gas offered further incentive to undertake a gas injection program.

Cost Factors

Comparative economic analyses indicated that cost of instituting a gas injection project would be considerably less than the cost of other programs investigated.

This factor, coupled with the potentially higher recovery that could be obtained by more efficient drainage of updip oil, led to the inception of a gas injection program in the Camerina "B" sand. No difficulty was encountered in securing approval of royalty interests to form a unit for the purpose of conducting a secondary recovery program in the Camerina "B" sand.

Production from the "B" sand was voluntarily reduced to lessen possibility of flooding out downdip wells before the gas injection program could be placed in operation.

Gas was first injected into the Camerina "B" sand in August 1950 through Unit Well No. 17, a centrally located well that had penetrated the "B" zone about 300 ft below the estimated pinchout. Oil production was restricted to approximately 400 bbl per day to allow reservoir pressure to build up while over-injecting at rates which varied from 2 to 2.5 million cu ft per day. By over-injecting, it was felt that the water level would remain at a relatively stable position or possibly be retired from the invaded area. Some evidence of recession of the oil-water contact was observed from producing characteristics of one of the low structure wells. In 1952 the allowable restrictions which had been voluntarily imposed were removed and production from the Camerina "B" sand from 1952 to 1955 averaged approximately 700 bbl of oil per day.

Back Flow Examination

Periodic backflowing of the injection well afforded the only means of examining the ability of the injected gas to migrate updip and move laterally throughout the pinchout region. Prior to 1955, production tests indicated that a gas phase had not been created to the level of the injection well since the injection interval would yield oil with a low ratio after backflowing for a period of a few hours. On the basis of these tests, it was concluded that injected gas had actually migrated to the top of the structure and that some lateral movement had occurred. In 1955, the gas injection program for the Camerina "B" sand was terminated to permit using injection facilities for a similar program in another reservoir. At that time a sustained backflow test of Unit Well No. 17 indicated that a permanent gas phase had been established to at least the depth of the injection interval.

Injection Results

During the five years over which the Cameron "B" sand injection program was conducted, 3.15 billion cu ft of gas were injected and approximately 1,000,000 bbl of oil were produced. Essentially all oil recovered during this period was displaced from the attic region of the reservoir. Water level was stabilized at approximately 9100 ft and pending floodout of additional downdip wells was prevented. It is believed that this program, which rightfully could have been called an experimental project in some respects, confirmed the practicality of injecting gas at downdip locations for the purpose of displacing updip oil where conditions are favorable for gravity segregation.

New Program for Camerina "D"

It was previously mentioned that the Camerina "B" sand program was discontinued in 1955 and the gas injection facilities were diverted to a similar project in another zone. At present, gas is being injected again through Unit Well No. 17, into the Camerina "D" sand; however, the purpose of the Camerina "D" sand injection program differs somewhat from the objectives of the Camerina "B" sand project.

Unlike the Camerina "B" sand, the Camerina "D" zone does not have an active water drive. To the contrary, natural water influx is so retarded as to be almost totally ineffectual in contributing to the maintenance of reservoir pressure. Absence of an active water drive was recognized at an early date and a pressure maintenance project by water injection was carried out in the "D" sand from 1945 to mid 1955. The program was terminated to prevent watering out a number of downdip wells by the artificial flood that had been created.

Gas injection into the "D" sand is being conducted principally to maintain reservoir pressure so that well producing capacity will not be impaired. Substantial savings can be effected by eliminating facilities that would normally be required for artificial lift and by reducing depletion life of this zone. A secondary, but important, consideration is the possibility that a natural water drive could manifest itself with further reduction in pressure and thereby floodout a number of low structure wells.

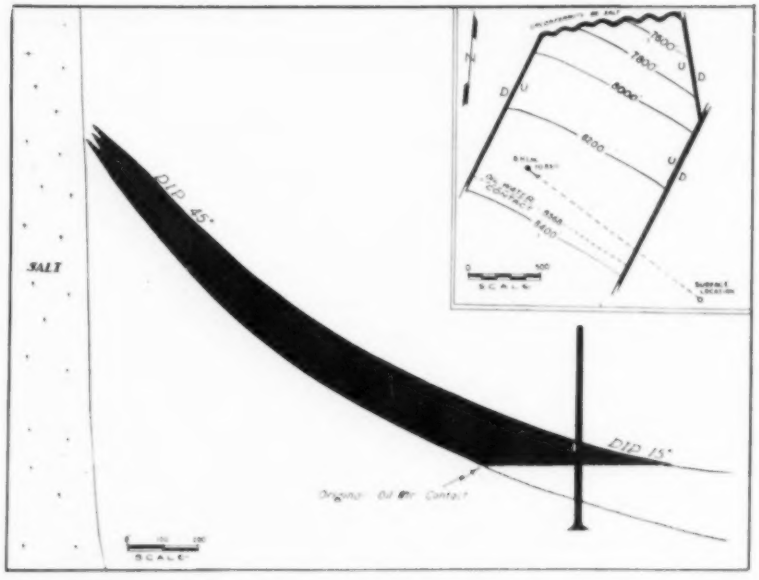


FIG. 4. **One-well pool,** dipping 45 deg. The well was taken off production, gas was injected until original oil-water contact is restored — building up production allowable credits in the meantime.

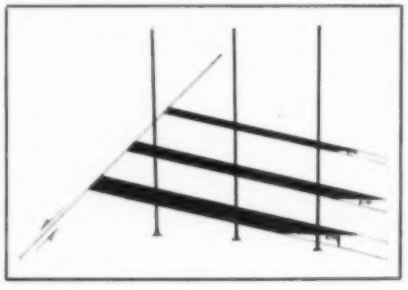


FIG. 5. **Downdip gas injection** techniques may find application in many faulted anticlinal structures where sidetracking or drilling of additional wells would be required, as shown by this unnamed field illustration.

Another One-Well Project

Another example of a downdip gas injection project is a one well program that was recently placed in operation in an offshore field (Fig. 4). The reservoir in question is bounded by faults on two sides and is sealed against the salt mass or an unconformity at the updip extremity. Downdip limit of production is defined by an oil-water contact. The only well in this reservoir penetrated the formation approximately 60 ft above the original water level. Within two years after completion, the well was producing 75 percent salt water. Gradual increase in water production, coupled with only a slight decline in reservoir pressure, indicated that an active water drive was operative in this zone.

Production, Injection Cycle

Faced with the prospect of an early floodout of the only well in this reservoir, the operator considered drilling a replacement well at an upstructure location. In addition to the high cost, however, the drilling of a replacement well was complicated by the necessity of controlling a directional hole from a platform located almost 2000 ft from the target area. Accordingly, downdip gas injection was advocated as a means of recovering updip oil and at the same time preventing floodout of the existing well. Gas is being injected at the rate of approximately 750,000 cu ft per day and the reservoir pressure will be allowed to build up until the water level has been retired to its original position. A production and injection cycle will then be conducted at about six-month intervals. Allowable credits will be accumulated during the injection period and the normal allowable plus the accumulated credit will be produced during periods of oil production. It is estimated that approximately 1,000,000 bbl of oil can be recovered in this manner, assuming all of the updip pore space is oil saturated.

Downdip gas injection is not limited to those reservoir conditions peculiar to the flanks of piercement type salt domes.

It is believed that this practice will have application in many faulted anticlinal structures where sidetracking or drilling of additional wells would normally be required to recover oil that remains in the apex of a fault segment. The latter is illustrated by Fig. 5. Here again gas introduced at a downdip location would have considerable merit as a method for efficiently recovering updip oil without incurring unnecessary drilling commitments.

It is believed that as the industry acquires more information concerning the role of gravity drainage in oil producing operations, an increasing number of situations will be found that will lend themselves to this particular recovery technique.

Acknowledgment

The author wishes to express his appreciation to the Pan American Petroleum Corporation (formerly Stanolind Oil and Gas Company) for permission to publish this paper. Presented at the Ninth Oil Recovery Conference, March 1956, at Texas A&M College, College Station, and published here for the first time. ★ ★ ★

Good sales tools important as "good iron"

Drilling Contractors' Silent Salesmen

Tell the world you're a top-notch contractor by every feasible method — from booklets and brochures to book matches and billboards

Eugene Whitmore
Sales Consultant
Lockhart, Texas

"NOT much to say about this business," one successful contractor told me. "We just drill and drill and drill . . . so many feet of hole and that's all there is to it."

I looked around this man's office. On the walls were excellent color photographs of spectacular rigs in almost bizarre surroundings.

"Where was this rig when the picture was taken?" I asked concerning one picture.

"Boy, don't mention that job to me. I nearly went crazy before we got that baby down to contract depth. Everything, and I mean everything, happened."

He launched into a thrilling account of putting down this well . . . and it was a well, too, that led to drilling others. In his account, the contractor gave me enough material for two or three sales presentation portfolios.

Drilling contractors often take a too-prosaic attitude toward their business.

When preparing sales material for a service organization, I am reminded of the song in The Mikado, "Do You Want to Know Who We Are?" For that is the first thing a customer wants to know. Who are you, where are you working, where did you come from, what have you to work with, and what do other people say about you? Are you good? Have you worked for some of the "top-dog" producers? What's your reputation? Have producers had pretty good success in bringing in the holes you have put down? What's your record for getting the job done on time?

And one more thing, Mr. Contractor: What have you done when you ran into some of the well-known headaches that beset every driller? Have you shown skill and resourcefulness in getting out of the difficulties? Have you proved that you don't fold up and quit when disaster or near-disaster strikes?

Who's Bragging?

"A lot of bragging on paper," one contractor mis-called this information. But that is far from the truth. A good sales presentation contains no bragging whatever. It is largely made up of pictures, figures and straight facts about the contractor's skill, experience and equipment to get the job done. In short, it's a straightforward application to do his job.

Perhaps the best way to lay out a contractor's sales portfolio is to break it into sections. Suppose we do that, starting with:

Section One

Brief history of the organization. Date founded.
Names of partners or active management men.
Brief resumé of their experience.
Outline of organization.
Pictures of owners, managers, drilling superintendents and other executives.

Section Two

Where have you operated?
Outline of areas where your organization has been most active. Probably a map showing location of majority of wells you have drilled.
Facts about type of wells drilled, depth, number and for whom.
Pictures of typical operations showing men and equipment in action.

Section Three

Equipment and facilities.
Several scenes in home office showing people at work. Prove that your accounting, billing and record-keeping operations are modern. Emphasize communication equipment if you have anything unusual.
Pictures of your yards, rolling stock, transportation facilities and all major equipment.

This then briefly outlines the facts that will help a producer decide whether or not your organization deserves a place on his approved list of bidders. And that, after all, is the first goal for any sales presentation.

Other facts may be included depending on your record, your facilities, your philosophy of business. The point is to tell and explain every fact which will help inform the producer, make him feel he knows your organization well enough to entrust you with a contract.

Presentation

The form or physical size and make-up of your presentation is the next consideration.

If you want only a few copies and do not plan to leave this material with prospects, a conventional three-ring binder with photographs in protective acetate envelopes, plus typewritten pages giving the data you want included, may do the job for you.

But remember, the pictures should be of professional quality, at least 8 by 10-in. in size. Do not rely on small snapshots made by amateurs. Your name or company name should be stamped in gold on a leather cover.

Date — Up to, or Out of

One advantage of such a sales portfolio is that it is easy to maintain and keep up-to-date. New pictures, new information can be added from time to time. Pictures have a way of dating themselves; automobile and truck models change from year to year, and a picture showing a 1948 truck may do you more harm than good. Discard old pictures, unless you want to use them to prove long experience in the field.

Informative brochures — sweet and simple or bold and colorful, as operations permit — are a must to keep the operator informed as to rig specifications, personnel, company data, and operational area. Everyone with whom you'd like to do business should have complete, up-to-date information on you and your equipment.

Make it easy for the operator to remember you! Company emblems — even on the crews' tin hats—lets everyone know you have men and equipment you are proud of.

Every man in your organization who visits producers, who contacts the men who let contracts, should have one of these portfolios. They are also a good aid for other company men who contact suppliers, government officials, county officers, highway officials and others whose good opinions of a contractor may smooth the way toward swift and trouble-free completion of a contract.

Data Booklets

Some contractors feel they also need another type of sales portfolio — a booklet containing the data outlined in the preceding paragraphs but in printed and bound form. After visiting a producer, the contractor or his field men like to hand one of these printed portfolios to him. Or they might be mailed to producers with whom the contractor hopes to do business.

While some printed portfolios are large, elaborate and very impressive jobs, the average contractor may not want anything so expensive.

Usually, the most effective piece is about 8½ by 11-in., a size easily slipped into any letter file and kept for reference. Because larger portfolios are too big even for legal-size filing drawers, the producer finds them difficult to keep handy for future reference.

Costs of printed pieces vary according to number of pages, paper stock used, number of colors, and art work used. While color illustrations are highly desirable, the cost of color plates may be prohibitive unless the contractor plans to use a fairly large quantity — say, 5000 or more.

Silent Salesmen

An important advantage of a printed piece is that it can be mailed to those whom the contractor finds difficult to contact. Or if the contractor is absent from his office, it can be left on his desk. Also, in larger producer organizations several men have a hand in deciding who goes on the approved list of contractors and who is awarded contracts, and printed material can be the "silent salesmen" who sits in with them to help do the job.

It is important to mail a copy of your portfolio or booklet or brochure — whatever you want to call it — to *all* executives in producer organizations who may be called on to help select drilling contractors. The more these men know about a given contractor, the more information they have about his experience, equipment, organization and ability to get the job done, and the more they are likely to put their stamp of approval on a contract.

One final suggestion in building a sales presentation. Think of it this way: the man who gives me a contract to drill may be called on the carpet by his boss or by a committee to explain why he awarded me the contract. If you have given him a sales presentation, it will come to his rescue. Do not ask him to remember everything you told him, do not ask him to remember the various reasons he had for awarding you the contract. Do the job for him. Include in your sales presentation everything—and I mean everything—which will in any way be a factor in justifying the award of the contract to you.

If you will do this, you will get contracts which producers are afraid to award to another driller simply because they do not know as many good points about the other fellow as they know about you.

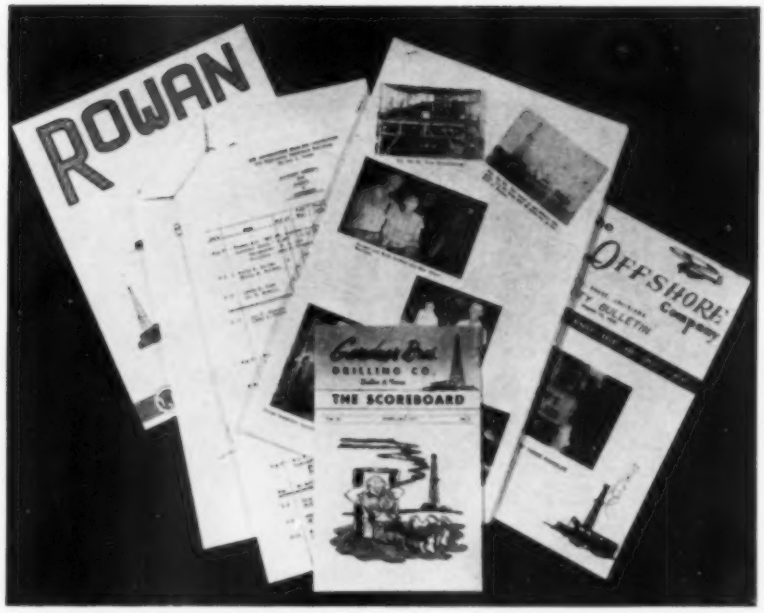
Just A Beginning

Many successful oil well drilling contractors do not stop with a smart sales presentation. They utilize many different means of reminding customers and prospects of their ability and equipment to serve.

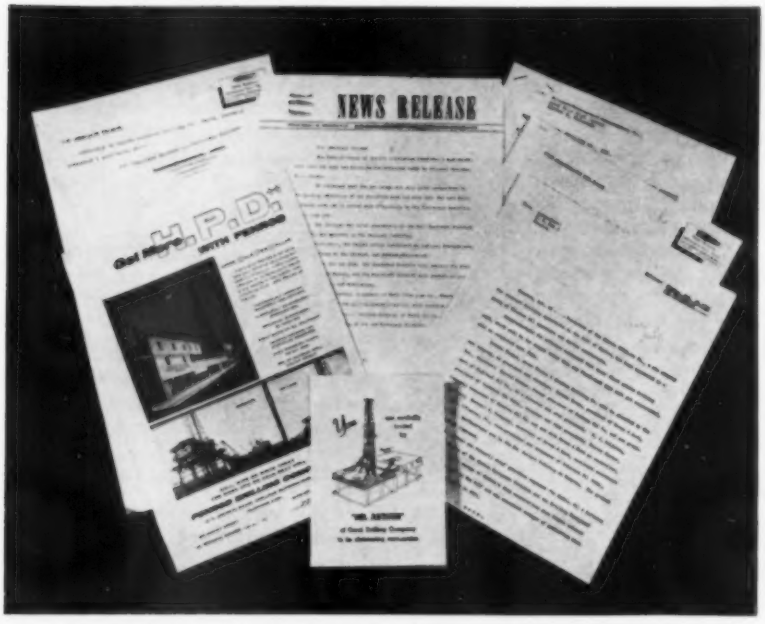
Some of the other methods are: Letters, company magazines, news letters, calendars, advertising specialties, highway signs, well-painted and lettered rolling stock and equipment, and good identification of all property such as warehouses, offices, storage and material yards, and on-site signs.

Some of the completion and workover companies have been especially active in using various kinds of adver-

Sales portfolios in the hands of the operator should provide a permanent record of everything considered valuable in awarding a contract



Safety bulletins in the hands of an operator tells him you are a man who cares for his men and is safety conscious — not to mention the effect it can have on your own men. These bulletins often include personal items and can create strong company ties among widely scattered rig personnel.



News releases: notices in changes, transfers, promotions among personnel, a safety record or drilling record — all find ready approval by newspapers and trade publications. Well placed advertising, calendars, direct mail letters, all serve to supplement a successful selling program.

tising, and their methods could be more widely used by drilling contractors.

Service companies in acidizing and fracturing use highway signs on roads leading into towns where they have a branch. Patterson Drilling Company employs attractive highway signs in its operational areas to remind producers that the company has both shallow and deep-well drilling equipment.

The Name's the Thing

With all the various media available, the drilling contractor finds it necessary to make a plan. How wide a territory does he want to cover? How many people does he want to reach? How often does he have a message for these people? And of course the big question: How much money does he want to spend?

Starting with the most obvious means of advertising at hand, every contractor has a group of traveling billboards, if he would use them. His rolling stock, including the passenger cars used by the staff men, may be lettered with colorful wording and designs to call attention to his business. Many contractors enjoy year-'round advertising value from their cars and rolling stock.

Home Base

Next comes the contractor's headquarters. If the offices are in a skyscraper — as some are — there's no opportunity for advertising except on the lobby directory. But if the contractor occupies his own building, by all means have it attractively identified. Same with other property such as garages, warehouses, equipment and supply yards. Every opportunity to say, "Here is a progressive drilling contractor," is worth capitalizing with the contractor's advertisement.

A well-kept property identified as a unit of the vast petroleum industry is just one more item in the industry's public relations program. It is helpful to the entire industry to have every well-kept drilling property identified. It shows the public the endless scope of the petroleum industry.

Sightly Drill Site

At the drill site some sort of an attractive sign is helpful. First, it guides suppliers; second, it answers the inevitable question, "Who's drilling this

Contractors with well-identified rolling stock enjoy year-round advertising, illustrate to the public the endless scope of the oil industry

Properly identified rolling stock and rig equipment is of decided advantage by keeping the name before the public and more specific, the operator. Good identification of all property, including warehouses, offices, yards, and on-site signs are all signs of the successful contractor.

hole?", and third, it establishes confidence in the contractor because the sign is proof that he is proud of his equipment, organization, and work.

Every piece of equipment visible to the public, if it is well-kept and policed for neatness, can be lettered with the contractor's advertisement.

Other means of advertising include book matches. Several contractors have told me they find these little books of matches useful as ice-breakers in interviewing new contacts, and friend makers in the community.

'Specialties'

On up the price scale from book matches come all sorts of useful specialties: Pens, pencils, rulers, tape measures, cigarette lighters, each item with the contractor's name and selling message. Calendars, both for walls and desks, have been successfully used by many contractors.

In my recently published book, "Building Your Business with Calendar and Specialty Advertising," you will find, "The one thing every business needs, above all others, is more friends." We see no reason why this does not apply to the drilling contractor. Never have I heard a drilling contractor talk about his customers without referring to the friendship built up around mutual interests. Many contracting businesses are built on wholesome friendships with producers. Other things being equal, the contractor who wins a contract is the one who has a friend in the producer organization. So it seems worthwhile to consider these various useful items of advertising to establish and maintain wider friendship.

Strictly Personal

Some contractors rely on personally written letters sent at fairly regular intervals to producer executives. These letters are a service to the producer. They tell of current activities — where rigs are at work, when they will be at liberty, purchases of new equipment, and other news which may be helpful to the producer.

Larger contractors publish news letters somewhat similar to those from various business services or to those sent out by association secretaries. These news letters, usually printed in typewriter type and broken into fairly short paragraphs, tell of the contractor's current activities, wells he has brought in, new equipment purchased, and news about his personnel — especially additions. Idea of the news letter is to keep all possible prospects informed about the drilling contractor's activities and to make the producer think, "Here is a progressive contractor. We should give him a contract."

For the very largest contractors, a small magazine with illustrated features, may be used. Such a magazine should be produced by a professional writer and needs to be well edited and printed. It is justified only in the case where a considerable amount of news originates in the contractor's organization or is available as a result of his contacts.

'It Pays to . . .'

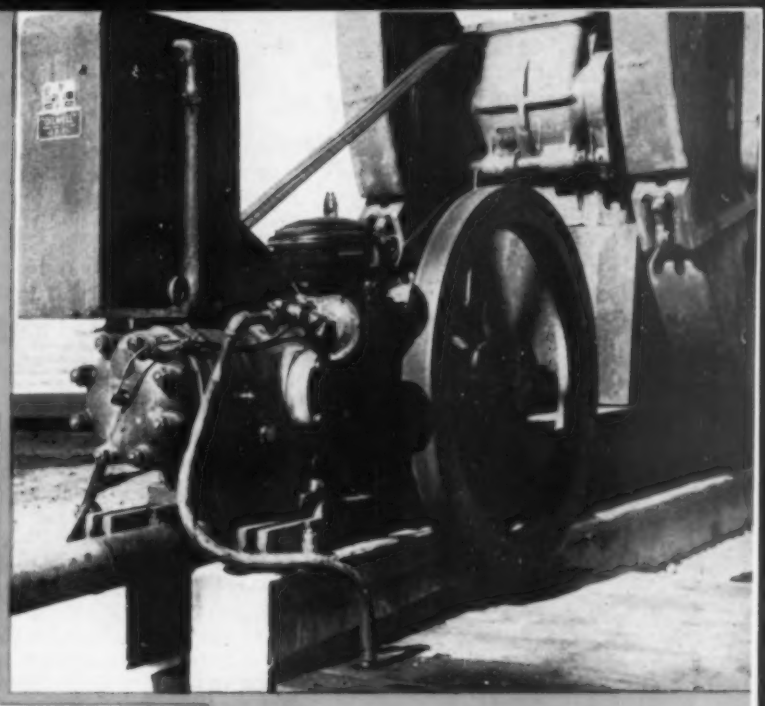
To a drilling contractor who feels the need to reach more people, of course other usual advertising opportunities are available. These include newspapers, the oil industry magazines, directories, and a host of more or less "fringe" media—such as one-time shots in programs, anniversary issues and special issues of various publications.

Contractors who have done the most thinking about their advertising and selling job have worked out a formula for judging media and advertising effort. Summed up, they say, "Be sure you have something to say that is worth saying. Be sure that the medium which carries your message will reach the people you want to serve." Any other type of advertising or sales promotion effort is wasted.

Acknowledgment

Grateful acknowledgment is extended to the many alert drilling contractors who have helped make this article possible, and who have illustrated the "proof of the pudding" by their own successful operations. ★ ★

In the 20-70 hp. range...



...**"Oilwell" Specialists in Production Equipment Recommend**

Lorain Gas and Diesel Engines

for dependable low cost PUMPING Power

● Winter's cold or summer's heat does not impair the consistently good performance of these heavy-duty two-cycle pumping engines.

Their slow-speed design enables them to stay on the job for years without costly repairs and with very little attention.

BRIEF SPECIFICATIONS

	Type L	Type O	Type R	Type A
Bore and Stroke, in.	7½ x 8	9½ x 10	12 x 13	13 x 13
Displacement, cu. in.	353	708	1470	1725
Speed Range, rpm	300-600	250-500	200-350	200-350
Max. Piston Speed, ft.	800	833	758	758
Rated Horsepower	14-25	24-42	35-59	37-70

Cylinder liner is of the wet type and can be replaced without special tools. Even when repairs are necessary, they can be made right on the lease, without the expense of trucking the engine to a shop.

Lorain engines, as well as maintenance supplies, are available at your nearest "Oilwell" store. Try one on your next heavy-duty pumping job and see for yourself how economical they are to operate.

OIL WELL SUPPLY
DIVISION
UNITED STATES STEEL CORPORATION

Executive Offices—DALLAS, TEXAS
Export Office—
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NEW YORK 20, N. Y.

Area Offices — CALGARY, CANADA
CASPER, WYOMING . . . COLUMBUS, O.
DALLAS, TEXAS . . . HOUSTON, TEXAS
TULSA, OKLA. . . . LOS ANGELES, CALIF.

Branches Serving All Oil Fields

USS TRADE MARK

"OILWELL"

TRADE MARK

UNITED STATES STEEL

Selection and placement of gas anchors, downhole pumps:

Keys to Effective Down-Well Gas Separation

John R. Brennan
Chief Engineer
Fluid Packed Pump Company
Los Nietos, California

OIL occurring in oil reservoirs is associated with varying quantities of water and gas. Both the water and the gas entering the well bore must be produced in order to produce the oil. In the early life of a field, when the reservoir pressure is high and wells are flowing, gas assists in lifting oil efficiently.

This is generally accomplished by shutting in the casing, and permitting sufficient pressure to build up in the annulus between the casing and the tubing to cause the well to "flow" up the tubing. When this occurs, oil, gas and water rise up the tubing in a frothy mixture and pass through the flow bean into the flow line. In this case, an actual bottom-hole mixing rather than a bottom-hole separation occurs.

Down-well separation of gas and oil becomes desirable when the well must be pumped. If there is no separation the gas must go through the pump. When it does, it takes up displacement that would otherwise be utilized for oil. If an ideal separation of gas and fluid could be accomplished, all of the gas would flow up the annulus between the casing and tubing and would enter the gas gathering system or flow line at the casing head. The de-gassed fluid would enter the suction of the pump and be produced up the tubing. It would then enter the production flow line at the wellhead.

Actual separation of the gas from the fluid is accomplished by gravity. Bubbles will rise through oil at a rate dependent principally on the viscosity of the oil. Tests have shown that the rate of rise of bubbles in water is more than 6-in. per second. To separate gas from the oil, it is necessary to cause the oil to flow downward at a rate less than the rate of rise of the bubbles. If the downward velocity of the oil is greater than the rate of rise of the bubbles, no separation will occur. Assuming a constant production rate, the only way to decrease the downward velocity is to increase the down-pass area. Thus it is apparent that the most perfect gas separator possible would be the one with the largest down-pass area possible within the space limitations of the casing.

Closest approach to an ideal gas separator occurs in wells where it is possible to set the pump at a point below the lowest entry of gas into the well bore. When this occurs, the entire annular space between the tubing and casing (or liner) becomes the down-pass area of the separator. Unfortunately, this ideal situation seldom occurs. In many wells, it is undesirable to run the tubing all the way to the bottom. Also, in most wells, there is some entrance of gas through the entire perforated section, and pumping near the bottom would still permit gas to enter the pump. It is therefore desirable in most cases to accomplish the separation directly beneath the pump so that the point of gas entry (whether above or below the pump) is of little significance. This is done by means of a gas anchor.

"Poor Man's" Anchor

A form of gas anchor frequently fabricated in the field is known as the "poor man's" anchor (Fig. 1). There are numerous designs on the "poor man's" anchor, but it usually consists of a joint of tubing run directly under the pump shoe. This joint is perforated at the top and bull plugged at the bot-

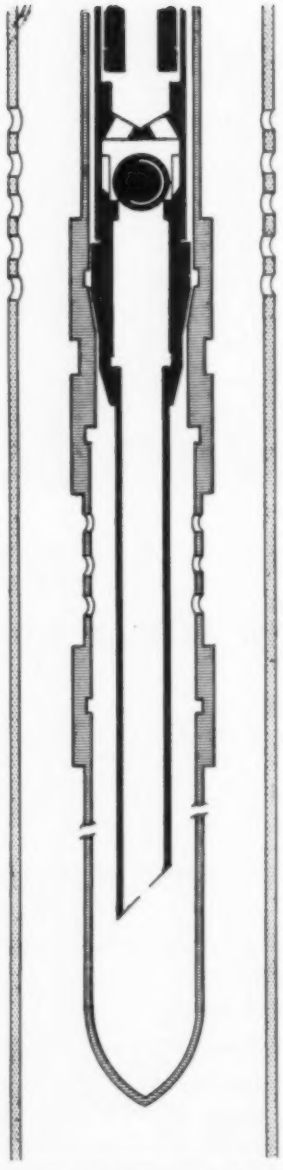

FIG. 1. **"Poor Man's" gas anchor is frequently field-fabricated. It is usually run with either bottom anchored pump or tubing pump, with a "skeeter bill," or top anchored and run immediately below the shoe.**

Prepared for and presented at the West Texas Short Course on Oil Lifting, April 19-20, 1956, sponsored by the Petroleum Industry of West Texas in cooperation with the Department of Petroleum Engineering at Texas Technological College, Lubbock, Texas.

tom. Inside of this joint, and serving as a suction to the pump, is a section of line pipe, frequently called a "skeeter bill." This pipe extends for some distance below the bottom of the perforated section of the anchor.

In the operation of the gas anchor, the gas-oil mixture flows into the well bore from the producing formation through the perforations in the casing. The larger bubbles tend to rise directly to the surface of the fluid and separate out as free gas in the casing. A portion of the medium and smaller bubbles are drawn into the perforations of the anchor by the suction of the pump. As this oil-gas mixture is drawn downward through the body of the anchor, the bubbles tend to rise to the top of the anchor and accumulate and break free as larger bubbles. As more bubbles rise, the descending fluid becomes less agitated and the smaller, slower rising bubbles have opportunity to become separated from the oil. Thus, as the oil descends in the anchor it becomes increasingly gas free and, if the anchor has sufficient capacity, the pump through the skeeter bill will deliver oil entirely free of entrained gas.

Actually, the amount of vertical drop required is comparatively small. Except where the problem is one of foam separation, a very few feet is adequate. The important factor is to provide as large an area as possible in the down-pass to minimize the fluid velocity and reduce the entrained gas carryover. The maximum outside diameter of the anchor must be somewhat smaller than the inside of the casing or liner in which it is hung. Since some separation occurs at the anchor perforations, sufficient clearance must be provided between the anchor and the casing to prevent an excessive turbulance outside the perforations.

An anchor of this type is run with either a bottom anchored pump or a tubing pump. Where a pump is top anchored, the gas anchor is run immediately below the shoe, and the pump itself extends into the anchor and takes the place of the skeeter bill in the "poor man's" anchor. This anchor enjoys the advantage of having the standing valve submerged in the fluid, but it does have a smaller down-pass area and consequently less separating capacity than a properly designed conventional type anchor.

Before selecting the down-well gas separating equipment for a well, the operator should analyze the particular problem that makes gas separation difficult in his well. Although a good gas anchor should assist in any gas separation problems, the choice of the optimum gas anchor and pump may vary with the individual well conditions.

Separation Problems

Most wells with separation problems will fall into three major classifications. Although the problem may involve more than one of these three, a careful analysis of conditions should indicate which one is primarily responsible for limiting separation.

1. **High gas-oil ratio wells.** Character of the fluid in wells of this type is such that the gas separates readily from the oil. Because of the large gas volumes involved, however, a gas separation problem is created.

2. **Oil-foam forming wells.** In these wells, gas separates very slowly and makes good pump suction difficult. In this classification may be placed the heavy oils, where the entrained gas leaves the oil very slowly.

3. **Gas-saturated-oil wells.** Gas dissolved in the oil is near the saturation point in wells of this type, and differential pressure across the standing valve liberates free gas as the oil enters the pump.

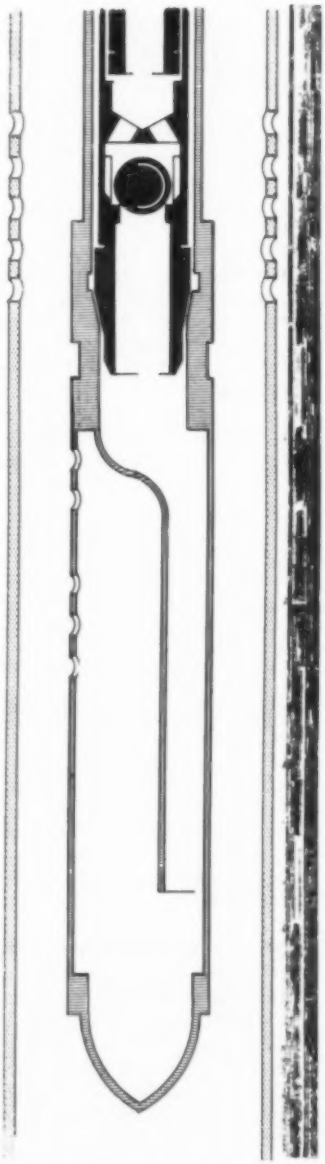

FIG. 2. **Marsh gas anchor,** because of the baffle at one side of the anchor, has a larger capacity than the "skeeter billed" "Poor Man's" anchor. In this, the hydraulic radius of the separating chamber is increased, thus increasing the slip velocity of the entrained gas bubble.

General Installation

In all installations where gas separation is a problem, it is assumed that some gas will be pumped with the fluid. Therefore, it is desirable to design and operate the pump in all cases to produce both gas and oil with a minimum loss of efficiency. The most important contribution to pump efficiency lies in properly spacing the down-hole equipment. When properly spaced, the traveling valve will come very close to the standing valve at the bottom of the stroke. This will reduce to the minimum the amount of stroke wasted on each cycle expanding and compressing gas. It also reduces the possibility of a complete gas lock. In a gas locked pump, gas pressure inside the barrel is sufficient to keep the standing valve closed at the top of the stroke, but is not sufficient to open the traveling valve at the bottom of the stroke.

The need for close spacing brings up additional problems in the case of a tubing pump. The standing valve puller normally run on a tubing pump makes close spacing impossible. Where gas separation conditions are severe enough to justify the additional disadvantage of pulling the well wet, a rigid type oversize standing valve can be run. The traveling valve can then be spaced to stroke very close to this.

A stationary barrel pump is preferable in gassy wells. The fluid, in order to enter the pumping chamber of a traveling barrel pump must pass up through the pull tube and plunger. In a stationary barrel pump, the fluid is in the pumping chamber as soon as it passes the standing valve at the bottom of the pump. As an additional advantage, the standing valve is larger on a stationary barrel pump (where it is in the barrel blind cage) than it is on a traveling barrel pump (where it is in the plunger top cage).

It is important that the stationary barrel pump be equipped with a blind cage at the bottom of the plunger so that close spacing of the valves is possible. This is general practice in most pumps, but in many of the soft packed plungers and in tubing pumps equipped with garbutt rods, the valve is at the

top. If it is desired to double valve a plunger, the second valve can be run either in a plunger top cage or in a double valve blind cage at the bottom of the plunger.

High Oil-Gas Ratio Wells

Solution to a gas separation problem is to provide adequate separating capacity. This is generally accomplished by running a gas anchor underneath a tubing pump or bottom anchored insert pump. If the volumes are small, the "poor man's" anchor may be adequate. If larger volumes are involved, some design of anchor should be adopted that utilizes more effectively the relatively small area available within the well bore. If this well has large casing, it is possible to run an "oversize" gas anchor, or one which has a larger outside diameter than the OD of the collars in the tubing string. Frequently, very good separation can be established in this manner since the oversize anchor provides a large down-pass area and consequent low vertical velocity. An oversize anchor is considered bad production practice in a sandy well, since it presents an enlarged section at the bottom of the tubing. If the well sands up covering this enlarged portion, it greatly reduces the possibility of pulling the tubing free from the sand. It is only in exceptional cases that an operator will risk the possibility of a washover fishing job in order to enhance gas separation. This alternative should be approached with caution.

Marsh Anchor

Fortunately, gas separation problems can be effectively handled in most cases by use of normal sized gas anchors, the OD of which is no larger than the tubing collars. By holding to this diameter and fabricating the anchor out of thinwalled tubing, it is possible to approximately double the down-pass area of a similar anchor constructed of upset tubing. The Marsh anchor (Fig. 2) offers a further refinement on this by substituting a baffle at the side of the anchor for the skeeter bill normally run down the center. This effectively increases the hydraulic radius of the separating chamber with a resulting increase in the slip velocity of the bubbles and a consequent increase in the capacity of the anchor.

Efficiency of the down-well pump is the yardstick by which efficiency of the gas anchor is measured. If possible, pump efficiency should be calculated as accurately as possible before and after any changes are made. If after installation of the anchor, efficiency is still low, different setting depths on the tubing are frequently tried. If the anchor is in the perforated section, lowering the pump will sometimes put the suction below the point of principal gas entry and permit a better suction. In other wells where the gas entry is large all the way to the bottom, a better separation can sometimes be effected by raising the anchor above the top of the perforated section. This reduces the turbulence between the casing and perforations of the anchor and permits a better separation to occur at the inlet ports.

Where a well is completed with an insert liner, it is usually advantageous to set the pump above the top of the liner except in cases where low reservoir pressures make it desirable to draw down the fluid level in order to keep the back pressure off the face of the formation. The velocity of fluid passing the anchor hung in the casing would be much lower than it would be in the restricted annular space of the smaller liner, and separation should be more effective.

Packer Anchor

In special cases of wells completed with small liners, the "packer anchor" finds an application. A packer equipped with a tail pipe which will run to the bottom of the well is set in the casing immediately above the top of the liner. A conductor pipe above the packer carries the gas and oil to a point above the suction of the pump. In operation, the well flows by its own pressure through the tail pipe and conductor pipe, and discharges into the casing. Oil then drops down to the pump suction and the gas rises up the casing. The cross section area of the casing less the area of the tubing and conductor pipe becomes the effective down-pass area, and efficient separation can be accomplished.

Summarizing, in high gas-oil ratio wells, a stationary barrel insert pump or a tubing pump and a well-designed gas anchor are the best general application. The best setting point for the anchor must frequently be determined by trial. Pump efficiency should be used as a measure of how successfully the anchor is separating the gas.

OIL FOAM-FORMING WELLS

In wells that tend to form foam, frequently the time required to separate gas from the foam so that solid fluid could be pumped is too great to permit a reasonable rate of production, and much of the gas must necessarily be produced through the pump. It is well to remember when designing these installations that foamy oil is a relatively homogeneous mixture of non-compressible liquid and highly compressible gas. The down-well pump may very well operate at close to 100 percent efficiency based on this mixture, but when compared to oil as gaged in a tank after ample separating time has been allowed, the pump efficiency may be as low as 10 or 20 percent.

The most practical solution is, therefore, to provide adequate production capacity in the down-well pump to displace both the oil and the gas at the existing well conditions. It is probable that the foam is formed in the producing formation just adjacent to the well bore. The dissolved gas breaks out of solution and expands as the oil is driven by the higher pressure of the reservoir

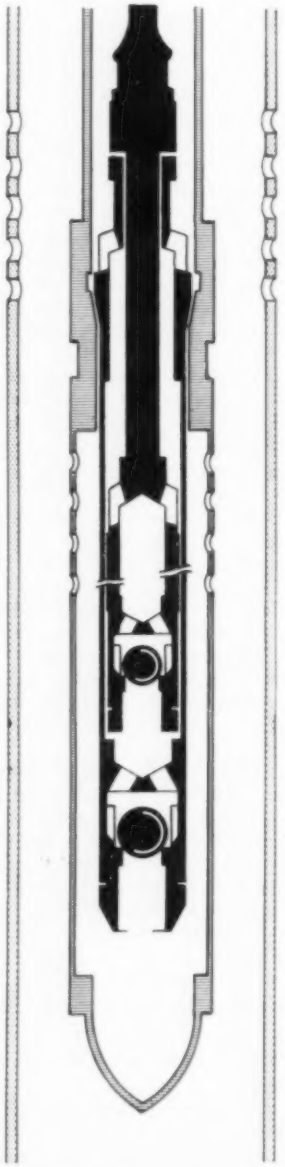

FIG. 3. **Immersion-type gas anchor** has proved best, in many cases, in pumping foam-forming wells. When this type unit is top anchored, the pump itself takes the place of the up pass area in conventional gas anchor. Standing valve is submerged inside the anchor, in the fluid being pumped.

into the lower pressure of the bore hole. In its final expansion into the well bore, a relatively stable foam is created.

Immersion-Type Anchor

Some entrained gas will be separated in a good gas anchor even in a relatively stable type of foam, and a top anchored pump in an immersion type anchor (Fig. 3) has proved to be the best under these conditions. In this type of installation, the pump itself takes the place of the up-pass area in a conventional gas anchor, and the standing valve is submerged inside the anchor in the fluid being pumped, permitting the head of separated fluid surrounding the pump to aid in filling the pump on each upstroke.

In foamy oil, it is important to pump from as deep a point as is practical in the well. If conditions permit pumping right from bottom, a higher efficiency (based on tank oil) will be obtained. If the well is a gun perforated completion and there is a section of blank pipe below the perforated interval, no gas anchor need be run if the shoe is set down in this natural sump formed in the bottom of the well. Such a completion forms the finest possible down-well gas separator.

The Author

John R. Brennan joined Fluid Packed Pump Company as sales engineer in 1948. He was graduated from Oregon State in 1937, entering Union Oil Company's training program the same year. Brennan worked as an engineer in gas operations until entering the Air Force in 1942. Upon receiving his discharge as a Captain in 1946, he was employed as dynamometer and pressure bomb operator before going into reservoir engineering work. Subsequently he worked as assistant production foreman then as engineer in drilling operations. He was promoted to chief engineer at Fluid Packed Pump in 1954.

This description indicates that it is not possible to separate — with any degree of efficiency — the gas entrained with the oil in a stable type of foam. Therefore, it is important to run a pump that will tolerate this quantity of gas with the greatest efficiency. Until recently, the best recommendation was simply to space the pump as closely as possible, thereby raising the compression ratio to a point where the valves would operate on every stroke and the pump would not go into complete gas lock. In addition to low efficiency, a bad gas pound is characteristic of a conventional pump operating in foamy oil.

The ratio-compound pump was introduced recently to improve efficiency in foamy or gassy oil, and to eliminate fluid or gas pound. It is essentially a stationary barrel (either top or bottom anchored) pump, but a long hollow polished rod replaces the pull rod and the top of the pump barrel terminates in a short packoff barrel closely fitted to the hollow rod. It contains the normal standing and traveling valves but a third valve controls the fluid flow through the hollow rod, and the annular chamber between the polished rod and the pump barrels serves as a second pumping chamber. Thus, we have a compound pump that will act as a two stage compressor on gassy fluids. The ratio between the area of the pump barrel and the annular chamber is about 2:1, and in fluids containing over 50 percent gas, all of the fluid will be displaced and the gas compressed during the downstroke into this smaller annular chamber. Since the plunger is sealed off from high pressure during the downstroke, no fluid pound can occur, and the traveling valve in the plunger is actually subjected to a suction force from the top instead of the high pressure of fluid in the tubing when the downstroke begins.

The ratio-compound pump has proved to be excellent to run in foamy oil since it improves pump efficiency due to eliminating gas lock and improving pump valve action. Perhaps of greater importance is the fact that it eliminates gas or fluid pound, and greatly reduces the load range on the rods and gear box and, therefore, the horsepower requirements of the prime mover. This pump may be run either bottom anchored over a conventional gas anchor or top anchored in an immersion type anchor.

If a tubing pump is run, a comparatively short anchor should be used. In a longer anchor, more gas would be separated in the long down-pass, but more foam would be generated in the long up-pass before it reached the standing valve. Except in rare cases, the overall result would be a loss in efficiency.

To summarize, in pumping foamy oil, be prepared to accept a lower pump efficiency, run the tubing as close to the bottom of the well as conditions permit, and if it is not possible to get the pump below the point of gas entry, run a gas anchor and top anchor the pump. To improve pump efficiency, run a ratio-compound pump.

Gas-Saturated-Oil Wells

Treatment for this type of well is much the same as a foamy oil. The most important factor is to permit easy access of the oil into the pump bore. When running an insert pump, a traveling barrel type should be avoided. A top anchored pump would be preferable, since the standing valve is submerged in the fluid in an immersion anchor and filling the pump could be accomplished with very little pressure drop.

Pumping the well as close as possible to the bottom is advantageous, since holding some fluid head over the pump would permit it to fill with a minimum of gas coming out of solution. If the unit has the capacity, it is best to run the largest practical bore pump in order that the number of strokes per minute can be reduced. A certain amount of gas is flashed out of the oil at the start of each upstroke, and by reducing the strokes per minute, the losses from this factor are reduced. A "poor man's" anchor with a long skeeter bill should be avoided in this type of production.

Conclusion

This information is submitted only as a guide, and may not prove best in all cases. Oil wells rarely seem to follow the rules, and it is difficult to predict all that happens thousands of feet below in the well bore. It is a fact, however, that the best gas anchor cannot lower, and in almost all cases will improve down-well pump efficiency. Since higher pump efficiencies can permit use of smaller units, less horsepower, smaller rod strings, and increased equipment life, the problem has an important economic aspect. ★ ★ ★

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Abernathy Tells Senate Subcommittee . . .

DRILLING RIG REPLACEMENT LAGGING

Crude price increase—long overdue—was needed to halt decreased rig activity trend

DRILLING activity in the U. S. "is dropping as a result of loss of confidence on the part of domestic oil producers," American Association of Oilwell Drilling Contractors President Jack H. Abernathy recently told the Senate Subcommittee headed by Senator Joseph C. O'Mahoney, investigating the petroleum industry's price structure.

Continued uncertainty as to federal government policies regarding the oil industry threatens the future oil and gas supplies.

Calling the recent price increase for crude oil "long overdue," Abernathy, an Oklahoma City drilling contractor, said "an increased flow of funds to producers will stimulate development, upgrade drilling equipment, result in overall lower costs to the public for petroleum products, and will increase our nation's economic and military strength and security."

"Only the drill finds oil," Abernathy explained. "Over the years, more than 70,000 bbl of oil have been found per well drilled in this country. A decrease of 730 rigs operating for a one-year period will result in a loss of a billion barrels of oil — enough reserves to equal Europe's entire demand during the same period."

TABLE 1 — New Rotary Rig Sales

Year	United States
1947	500
1948	650
1949	175
1950	280
1951	385
1952	360
1953	270
1954	205
1955	275
1956	280

Abernathy pointed out to the Senate group that there has already been a marked decline in the number of drilling rigs at work. "For example, 2336 rigs are operating in the U. S. now, compared with 2535 one year ago and 3137 on December 19, 1955 — a reduction of 801 rigs in the 14-month period."

Referring to AAODC statistics, Abernathy said that, despite rising costs, contractors are drilling at 93 percent of 1941 footage prices, as a result of improved equipment and methods that enable them to drill almost twice as fast. On the other hand, the total cost of drilling (which includes services not furnished by the contractor), has more than doubled in the same period.

"Unfortunately, this process of meeting rapidly increasing costs by drilling more speedily has about run its course, using the equipment and know-how generally available to the drilling contractor at this time. Major technological and equipment improvements result from research on an industry-wide scale — and come about only when sufficient funds are generated by operations to pay for them. **Contractors on a whole have been unable to replace older, less efficient equipment, with new rigs during the past few years.**

"Some 60 to 80 rigs sold in 1955 and 1956 were for offshore work—a rather special case. It can be seen (Table 1) that new rig sales lagged far behind the rates of the late 40's and the early 50's, being only about 275-280 per year.

"In December 1953, the National Petroleum Council on Oil and Gas Exploration, Drilling and Production Requirements, released a report detailing quantities of materials to sustain a 50,000 well per year drilling effort (1956, 58,231 wells, Table 2). It was estimated in that report that rigs must be replaced at the rate of 453 per year. Allowing for additional rig productivity and adjusting for additional requirements, the industry appears to be liquidating about 175 rigs yearly.

"The only possible result of this failure to replace rigs is obsolescense which will lead to considerably increased costs—cost rises much greater than the relatively modest increases which would suffice to enable the industry to keep up to date.

"Our customers have been caught between static prices for crude oil and constantly increasing costs for everything they buy. Naturally they have applied over-severe price pressure on drilling contractors, thus limiting funds available for equipment.

"We drilling contractors are in the best possible position to know how hard the oil producer strives for efficiency and economy. We find this true of each operator for whom we work.

"The average rotary rig operating steadily drills about 19.5 holes annually thus about 1,370,000 bbl of crude oil are added to our nation's reserves per rig per year. A decrease of 730 rotary rigs operating for a one-year period results in a loss of a billion barrels of oil — enough reserves to equal Europe's entire demand during the same period.

"If the present trend of decreased rig activity (lowest since August 24, 1952) continues, this nation's outlook for an ample supply of domestic crude sufficient for emergencies is not good.

"Contractors' revenues have been reduced to levels too low to allow for equipment replacement because our customers, the oil producers, have been too-tightly pinched between relatively fixed prices for crude oil and increased costs for things they buy, other than footage drilled," Abernathy declared.

* * *

TABLE 2 — "The Lean Years"

	1935	1941	1956
No. of wells completed in U. S.	24,851	32,510	58,271
Total U. S. hole drilled, ft.	67,844,939	99,347,714	234,350,550
Average depth per well, ft.	2760	3056	4022
Average total cost, per ft.	$8.00	$7.25	$13.75
Average contract cost, per ft.	$5.00	$4.25	$4.75
Total well cost	$22,100	$22,100	$55,300
Contractors' charge, total	$13,800	$13,000	$19,000
Contract cost, percent of total	62.5%	58.5%	34.5%

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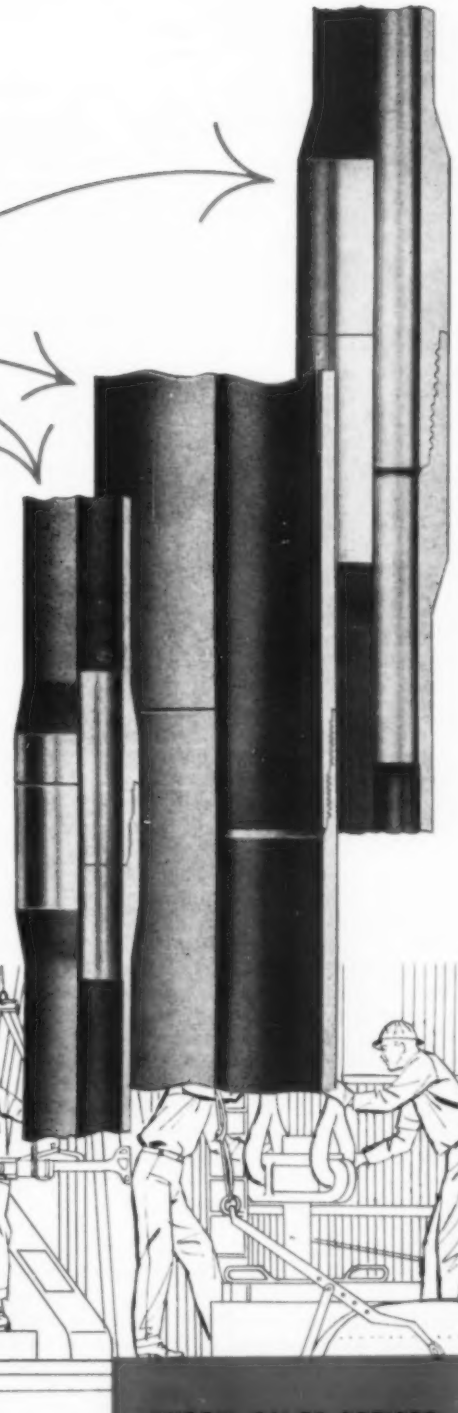

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- **Mud engineers make and maintain better mud**
- **Drilling engineers see fewer hole problems**
- **Operating companies realize barite savings**
- **Drilling crews enjoy "automatic" operation**

TREATING weighted drilling muds with the centrifuge is becoming increasingly prominent in today's drilling operations. It is fast becoming recognized as the key tool allowing the mud engineer to prepare and maintain low-solids muds needed to drill modern, deep, high-pressure wells with some semblance of economy. Its efficiency as a solids remover has been known for some time. Now, its versatility as a mud-engineering tool is being exploited.

Greatest value of centrifuging as a mud-engineering tool is based on problems of maintaining weighted muds. Even when no difficulties are being experienced, normal maintenance of high-density mud is very costly. Watering back such a mud has been an accepted procedure because fine formation particles, not removed by the shale-shaker screen or by settling in the tanks, become a part of the mud.

Presence of these fine, lightweight formation particles affects mud adversely in that they occupy space. Volume of the liquid phase is reduced when these additional solids are present. The character of these solids can be altered by chemical treatment so that more of them can be tolerated before a mud looses its desired properties, but eventually their concentration in mud must be reduced. Practice of watering back, therefore, has been necessary to maintain the mud in its normal range of properties. In high-density muds the problem is intensified by presence of large amounts of barite, which is the most expensive component of mud.

Amount of water that is added to mud at any given time depends upon the mud condition. Addition of 10 percent to the volume is common, and sometimes it is necessary to add 20 percent water to get a mud into proper condition. This is in addition to the normal amount of water that is always going into the mud while drilling is in progress.

Mud Diluting Cost

Remembering that as a certain volume of water is added to the system, room must be made for that water, economic factors involved in watering back a mud must be considered. Preparation of a new mud having a density, for example, of 17.0 lb per gal, will involve the use of typical amounts of materials as given in Table 1.

TABLE 1 — Cost of Preparing 1 Bbl of 17-Lb Mud — $15.85.

Material	Amount required, lb per bbl	Cost per lb	Total cost of material
Bentonite	6	.02	.12
CMC	1½	.90	1.35
Graphite	2	.16	.32
Quebracho	1	.18	.18
Caustic	1	.09	.09
Weight material	475	.026	12.35
			$14.41
(Handling and breakage—10 percent)			1.44
Total cost			$15.85

Cost of preparing a barrel of 17-lb mud is $15.85. Suppose that a 1000-bbl mud system needs to be watered back an amount that will require the jetting away of 100 bbl of mud.

Mud, after being diluted, must be conditioned with weighting material and sufficient chemicals to maintain the desired properties. In actual practice, conditioning takes place at the same time as addition of the water, and such additives as bentonite may not be used. Cost of getting the total system back to its original 17.0 lb per gal weight and the use of necessary chemical additives will amount to about the same as would the preparation of a new mud.

Conditioning the mud system by the watering-back method will, therefore, be equal in cost to the value of 100 bbl of mud worth $1585 that was jetted away plus the cost of making 100 bbl of new 17-lb mud — another $1585. The cost of this procedure will be $3170.

Centrifuging Cost

The centrifuge process eliminates the need for watering back mud because the drilled solids are removed mechanically. Barites are removed and returned to the mud system in the form of a heavy sludge. Sludge must be thoroughly mixed back into the rest of the mud in the tanks. Light solids and water and chemicals are discharged into the reserve pit as effluent.

If 100 bbl of mud are processed through the centrifuge, all of the chemicals will be lost and a small amount of barite will be rejected along with the clays, depending upon the efficiency at which the machine is being made to operate. Let us assume that the machine is throwing away 15 percent of the barite that it processes. Because there is $1235 worth of barite in 100 bbl of the mud, the centrifuge will recover 85 percent or $1050 worth of barite.

Chemicals in 100 bbl of this 17-lb mud are also lost in the process. Difference in the cost of mud and value of barite recovered represents the cost of centrifuging the mud. This cost must be in addition to the $1585 which was originally spent to prepare the mud.

TABLE 2 — Cost of Centrifuging 100 Bbl of 17-Lb Mud.

Original cost to prepare 100 bbl	$1,585.00
Cost of barites and chemicals lost in process	535.00
Total cost	$2,120.00

Total cost of centrifuging 100 bbl of 17-lb mud is $2120. This method compares with the method by which 100 bbl of mud is jetted away to be replaced by water and new mud as follows:

Cost of jetting and watering back	$3,170.00
Cost of centrifuging	2,120.00
Difference	$1,050.00

About $1050 can be saved by using the centrifuge just one time to keep the mud properly conditioned!

The watering-back method is still in common practice, and in some areas it is necessary to condition mud in this manner as often as three or four times a week. Where the centrifuge is made to perform properly, it is effectively removing solids in such quantity and over such a range of sizes that these larger water dilutions are not necessary; nor are the larger and often complicated chemical treatments of the past needed.

Centrifuge Construction and Operation

Reason that weighted muds can be profitably processed through a centrifuge is that the specific gravity of barite is 4.2 while that of formation solids averages about 2.5. Several manufacturers are now providing centrifuges that are adaptable for use on drilling muds.

A decanter type machine performs its separation by subjecting the fluid to centrifugal force while passing through a rotating cone. See Fig. 1.

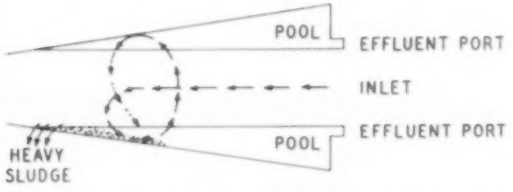

FIG. 1. **Mud flow** through a continuous type, or decanter type, centrifuge. Separation is performed by subjecting fluid to centrifugal force while passing through a rotating cone.

Mud enters the rotating conical bowl as a diluted slurry containing solids from the formation and heavy weighting material. When the feed mixture is first thrown against the walls of the rotating bowl, heaviest particles come out of the liquid and cling to the rotating wall. Size of the heavy particles determines at what point in the cone the centrifugal force is great enough to remove them. Force is greatest at the point where the diameter of the bowl is largest. Heavy barite solids that become stacked against the bowl are moved toward the smaller end of the bowl by a spiral conveyor inside the bowl. The conveyor moves in the same direction but at a slightly slower speed than the bowl. Barite is then discharged as a high density sludge through ports in the bowl.

Lightweight solids will not be thrown out of the feed liquid as easily as will the heavies and, therefore, will flow out of the bowl with the liquid effluent or overflow through ports at the large end of the bowl.

Rotating speed of the conical bowl will determine the amount of centrifugal force that is developed. Because of the shape of the horizontally positioned cone, there will always be fluid lying at the wide end of the bowl. When the bowl is rotating, the liquid will be thrown around the walls. This liquid forms the pool and its volume is determined by the position of the adjustable effluent discharge ports. If the pool volume is large, particles are retained for a longer period of time than if the volume were small. Therefore, the longer the particles are retained in the pool of liquid, the longer they will be exposed to the forces of rotation.

Two factors that most affect the centrifuge process are: (1) Centrifugal force, and (2) length of time during which the particles are subjected to that force. By using multiples of gravity or gees to express the centrifugal force and seconds to measure retention time, the useful term "gee-seconds" can be produced by simple multiplication.

If the pool volume is reduced, the fine particles will not be permitted to remain under the influence of centrifugal force long enough to be removed with the coarse particles. Some smaller barite particles will be rejected along with the clay in this case.

Particle Sizes and Weights

Size of particles of various densities affects separation.[1] If a mud contains weighting material having a specific gravity of 4.2 and formation solids having a specific gravity of 2.5, the process would present no problem if all particles were the same size and shape. Unfortunately, many barium-sulfate particles will be smaller than some of the formation particles. The separation process is effected by the size of particles as well as their specific gravity. Fig. 2 illustrates the particle-distribution situation that might exist in a drilling mud.

Curves show that it is impossible to separate and discard all clay solids and retain all of the barite. Frequently, as much as 15 percent of the barite present in a mud is less than 10 microns in size.[2] Next best approach, then, is to separate all of the clay possible and retain as much barite as possible. The cut necessary to make this type of separation would be at the point where the curves intersect at line (1). Some of the clays would be retained in the sludge and some barite would be retained in the sludge and some barite would be rejected with the clay in the effluent.

Centrifuge Applications

Relationship between mud control and centrifuge process is significant. If curves shown in Fig. 2 represent a weighted 12-lb per gal mud in a fast-drilling hole making a large amount

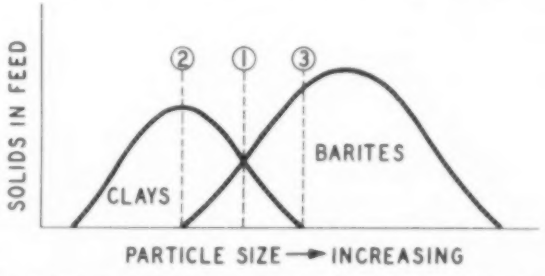

FIG. 2. **Possible types of separation** with the centrifuge. This illustrates the particle-distribution situation that might exist in a drilling mud.

of solids come into the mud, the mud engineer would decide to make a cut as shown by line (3). Here, he may actually throw some extra barite away in his effort to remove all of the drilled solids. He will consider economy and the need for a certain set of mud properties under existing drilling conditions as depth, drilling rate, and the type of mud he will need when the well gets deeper.

If the curves in Fig. 2 represent a 17-lb mud being used while the drilling rate is medium, it will be necessary to take a cut at the point where line (2) intersects the curve. This decision would require the engineer to run the centrifuge for longer periods of time until the drilling rate slows down. The condition of the mud is all important in such decisions. It is necessary to recover all the barite possible when centrifuging a heavily weighted mud, but it is more important to keep the best possible mud properties. The mud man may, therefore, have to slip the separation line back to the right of line (2) even though he will knowingly discard valuable barite.

The fallacy of using Fig. 2 to explain why different separations are necessary should be emphasized by pointing out that the distribution curves for particle sizes in a given mud are always changing. These distributions are dependent on the drilling rate, mud weight, and the amount of time which the centrifuge has already been run.

Solids Content of Mud

Several means are at the disposal of the engineer for de-

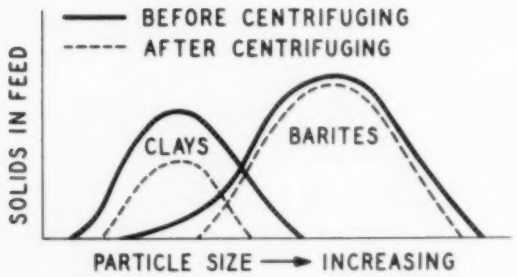

FIG. 3. **Particle size distribution** in centrifuged mud is continually changing.

termining the condition of his mud as related to solids content. They are:

1. Stormer viscometer.
2. Fann V-G meter.
3. Hand centrifuge.
4. Oil retort.

Use of the oil retort is one of the better methods of determining whether the mud is in need of centrifuging or chemical treatment. To use it or any of the other testers properly, the mud engineer must know what the properties will be when the mud is in the best possible shape. Suppose that a funnel viscosity of 50 sec API indicates that the mud is just as he wants it. He will also know that some higher viscosity, perhaps 60 sec, indicates that the solids content of the mud is approaching a critical concentration above which the viscosity will rise very fast and the mud will be in poor condition. By using the oil retort, he can determine the ideal solids content for that mud.

Case 1

If after several days of drilling, the funnel viscosity is climbing towards 60 sec, there is a need for a solids content determination. The solids content of the mud will usually be found to have increased. Table 3 shows some sample retort determinations.

TABLE 3 — Retort Method Indicates Mud Needs Centrifuging.

Funnel viscosity—50 sec	Percent	Funnel viscosity—60 sec	Percent
Oil	5	Oil	5
Water	64	Water	61
Solids	31 (ideal)	Solids	34 (undesirable — by vol)
Total	100	Total	100

This example would indicate that the mud needs to be centrifuged. In actual practice, the mud engineer will leave a standing recommendation for the crews to maintain the viscosity between 50 and 60 sec with the centrifuge. As far as the crew is concerned, only the viscosity is being controlled by the centrifuge. Either the solids content, as determined with the retort, or the funnel viscosity is a useful index to the mud man in keeping the mud right.

Case 2

Now suppose that the mud from Case 1 is found to have increased in viscosity to 70 sec. The retort method shows that the solids content remains unchanged. This would immediately indicate that the mud has been contaminated and requires chemical treatment rather than centrifuging. See Table 4.

TABLE 4 — Retort Method Indicates Mud is Contaminated.

Ideal Funnel viscosity—50 sec	Percent	Undesirable Funnel viscosity—70 sec	Percent
Oil	5	Oil	5
Water	64	Water	64
Solids	31	Solids	31
	100		100

Advantages of Low-Solids Muds

Advantages of low-solids, low-viscosity systems are well known to drilling engineers.[3] Pumps run better and parts need not be replaced as often. The pump discharges the fluid with less pressure buildup. The drill stem in which most of the pressure drop occurs can handle the same velocities at reduced pressures. More of the hydraulic horsepower which is expended inside the drill pipe and collars can be delivered to the bit nozzles in the form of greater velocities. The cuttings are removed more quickly from beneath the bit teeth and are not reground to finer particles. Velocities in the annulus, too, are greater. This helps keep the hole cleaner and brings the cuttings to the surface faster.

These advantages exist because the light formation particles are not present in the mud. The pump is not required to circulate them through the system. The additional pressure that must be used when the undesirable solids are present is no longer needed and can be used to gain other advantages.

This removal of drilled solids with the centrifuge has affected all phases of mud-engineering problems. New approaches are now being made to such situations as lost circulation, settling of cuttings, penetration rates, fluid velocities, and hole conditions.

Lost-Circulation Example

Use of the centrifuge and a working knowledge of flow properties must go hand in hand. This was shown during a lost-circulation problem on a wildcat well on the Gulf Coast. Following is a list of pertinent well data.

TABLE 5.

Well data		Mud data	
Depth, ft	11,925	Mud weight, lb per gal	17.0
Hole, in.	8½	Funnel viscosity, sec	62
Drill pipe, in.	5	Plastic viscosity, cps	41
Pump stroke, in.	20	Yield point, lb per 100 ft²	23
Liner size, in.	6		
Strokes per min	43		
Gage press., psi	1250		

As soon as mud loss was recognized the pump was slowed down from 43 to 28 strokes per min. This reduced the pressure from 1250 psi to 750 psi. The annular velocity was likewise reduced from 178 to 117 ft per min. Closer scrutiny was made to determine what the actual effect of slowing the pump down was in reducing the pressure of the circulating fluid at the bottom of the hole. The pressure-drop equation for laminar flowing fluids was used.[4]

$$P = \frac{lty}{225D} + \frac{nlv}{1500D^2}$$

Wherein:

P = pressure drop in pounds per square inch, over the length being calculated.
n = plastic viscosity of the mud, in centipoises.
l = total length, in feet, of the diameter being considered.
V = mean fluid velocity of the mud, in feet per second.
ty = yield point of the mud, in pounds per 100 sq ft.
D = bit size minus pipe OD, in inches for annular flow.

$$P_1 = \frac{11{,}925\ (23)}{225\ \ (3.5)} + \frac{(41)\ (11{,}925)\ (2.9)}{1500\ \ (3.5)^2}$$

P_1 = 425 psi (Bottom-hole circulating pressure at 43 strokes per min or 178 ft per min annular velocity)

$$P_2 = \frac{11{,}925\ (23)}{225\ (3.5)} + \frac{(41)\ (11{,}925)\ (1.95)}{1500\ (3.5)^2}$$

P_2 = 400 psi (Bottom-hole circulating pressure at 28 strokes per min or 117 ft per min annular velocity)

This calculation revealed that by slowing the mud pump down from 43 to 28 strokes per min the pressure at the bot-

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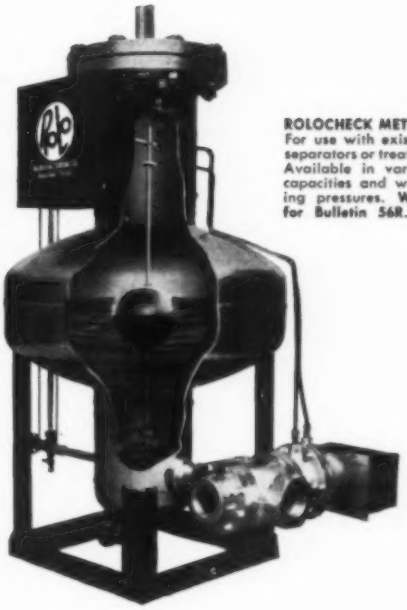

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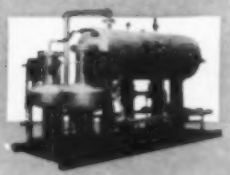

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tom of the annulus was reduced by only 25 psi. Though circulation is frequently regained by this method, the fact still remains that the pressure exerted on a weakened formation had not been greatly altered.

Next approach to the problem was to improve the flow properties of the mud. The centrifuge was used to further reduce the solids in the mud, and a small amount of water and chemicals were added for the purpose of reducing the yield point of the mud. The weight of the mud was not altered from its original 17.0 lb per gal. After conditioning the mud, the yield point had been reduced from 23 lb per 100 sq ft to 11 lb per 100 sq ft. Funnel viscosity was 50 sec.

Calculations were again made with the new mud properties as shown in Table 6.

TABLE 6.

Mud weight, lb per gal	17.0
Funnel viscosity, sec	50
Plastic viscosity, cps	41
Yield point, lb per 100 ft²	11
Pump strokes per minute	43

$$P_a = \frac{11{,}925\ (11)}{225\ (3.5)} + \frac{(41)\ (11{,}925)\ (2.9)}{1500\ (3.5)^2}$$

$$P_a = 166.6 + 77.2$$

$P_a = 244$ psi (Bottom-hole circulating pressure at 43 strokes per min after yield point of mud was reduced to 11 lb per 100 sq ft)

Conditioning this mud so that the yield value was lowered resulted in a reduction of the bottom-hole circulating pressure by 181 psi. This represents a significant improvement in the hydraulic system. Besides solving one particular lost-circulation problem, here is very definite proof of the effect of high yield points on circulating pressure. Formation solids in the mud cause high yield points. Reducing the pump pressure, as is the first tendency when mud is lost to the formation, actually gives only limited assistance to the problem at hand. The 500-psi change in the standpipe gage reading was in the most part caused by reduced pressure drop inside the drill stem where the mud is in turbulent flow. In turbulent flow a large decrease in pressure accompanies only a small reduction in velocity. Yield point of the mud is by far the most significant factor affecting the pressure drop when the mud is in laminar flow.

Practice of loading up a mud with lost-circulation materials in thief zones is fast losing favor in many areas. The presence of high concentrations of such materials in a mud imparts flowing characteristics to the mud which are more likely to increase than to decrease lost circulation. Materials that stop loss of mud can also be the cause of lost circulation. Best approach to this problem is based on having the mud in such condition that pressures due to mud circulation will be minimized.

Centrifuge Is Versatile

Centrifuging is the best means by which the yield point of a mud can be kept to a minimum value. Large chemical additions or large dilutions with water are also effective but their expense makes them objectionable.

If solids are not present in the mud, then need for thinning chemicals or water is diminished. This has been proved in actual practice. With a centrifuge at work on the mud, fewer chemical additives are required by the mud to keep it conditioned. A centrifuged mud, however, will require slightly larger amounts of water-loss control and suspending agents such as CMC. Some of the light solids which give the average mud its suspending and low-water-loss chacteristics are removed by the centrifuge and must be replaced.

Combats Contamination

The centrifuge process allows fresh water to replace salt-laden water in a contaminated mud so that the contaminant is removed. Considerable experience has been gained in treating out cement from weighted completion and packer muds. A high-pH lime-base mud can be converted to a low-pH conventional mud with the centrifuge.

History of a well near Bay City, Texas, is also the story of the versatility of a centrifuge. Cost of drilling this very troublesome land-based well was over a million dollars.

A high-pH lime-base mud was used to drill through 2000 ft of heaving Anahuac shale. During this time cuttings did not appear on the shale-shaker screen. Instead, soft mud balls were present in the mud indicating the type of problem the formation was presenting. Fifteen hundred to 2000 lb of lime were required each tour to keep the solids in the system converted to calcium. On drilling out of the shale at 7400 ft, a protection string was set and there was no longer a need for a lime-base mud. At this time lime content of the mud was 8 lb per bbl.

The centrifuge continuously processed the mud and in 10 days the 8 lb per bbl lime content was reduced to just a trace. The pH of the mud was maintained at 11.5 to 12.0 to preserve the starch which was still present in the mud. Later the pH was allowed to come down to a value of 9.5. This centrifuged mud was eventually used as a very fine completion fluid. Not a drop of mud had to be jetted away while drilling from a depth of 7000 ft to total depth, which was 14,500 ft.

Such low-solids centrifuged muds make very successful packer muds. High-temperature gellation is not a problem with such a fluid.

Salvage Reserve Mud

Phillips Petroleum Company's centrifuges are made to run about 75 percent of the time that drilling is in progress. When the centrifuge is not used on the circulating system in the well, it is frequently used to process mud that has been stored in a "ducks nest" or small separated section of the reserve pit. This mud may be processed into a good high-density packer mud which is stored in tanks for future use. It may process reserve mud and deliver the barite into the drilling well for weighting up purposes.

At one time it was the practice to locate discarded weighted muds in nearby areas and deliver them to a central location in the Chocolate Bayou field. The centrifuge would then retrieve the barite from the muds for use in weighting up or preparing other muds. The total cost involved in this method was usually the $1 or $1.50 per bbl for hauling the mud. Muds weighing 12 lb per gal and up were processed in this manner and ultimately saved the company considerable sums of money.

Operates During Trips

Sometimes drilling rates are so fast that the centrifuge has difficulty keeping the solids content down to the amount consistent with good mud properties. The centrifuge should then be allowed to run on the surface system during trips and other shut-down periods. This type of operation will permit the circulating mud volume to be reduced sufficiently to permit the use of more water and barite without having to jet away part of the weighted mud.

For example, during a trip 100 bbl of a 17-lb mud may be centrifuged. The light clay solids and liquid are discharged as effluent and the barite is returned to the pits as a 23 lb per gal semi-fluid sludge which is then redispersed into the system by agitation. Volume of the 23 lb per gal mud is 55 bbl. Water is added to keep the weight at 17 lb per gal in the mud tanks. Room has been made available for 45 bbl of water in the system without the need for jetting. Water can be added in such amounts as to condition the mud so that the viscosity is lower, the flow properties are improved, and part of the light forma-

tion solids have been removed. Conditioned surface mud when circulated through the hole again mixes with the rest of the mud and the system has been improved while the pipe was out of the hole.

Conclusion

To the mud engineer who works with weighted muds, the centrifuge has become a tool with which he can make and maintain better muds than ever before. He can control the funnel viscosity as well as other properties with the machine. To the operating companies the centrifuge has proven to be a means by which significant reductions in well costs are effected by barite savings. Drilling engineers see the centrifuge as a means to better penetration rates and fewer hole problems. Drilling crews like the centrifuge because it is automatic and foolproof. As the centrifuge runs, the crews are aware that the machine is saving them the work that would be required to add new materials to the mud.

Acknowledgment

The authors wish to express their appreciation to Phillips Petroleum Company for permission to publish this paper. This paper was presented at the spring meeting of the Southern district, American Petroleum Institute, division of production, Shreveport, Louisiana, March 20-22, 1957, under the original title "The Centrifuge and Mud Technology."

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3. Wheless, N. H. and Howe, Jack L.: "Low-Solids Muds Improve Rate of Drilling, Cut Hole Time," *Drilling*, 70, August (1953).
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Appendix

Centrifuge Calculations. Size of the pool volume is an essential factor in obtaining the best separation. The volume of the pool is determined by the position of the effluent ports as shown in Fig. A1. This volume may be determined by a simple calculation. The difference between the volume of a core and the volume of a cone will be the volume of the pool. Following are the calculations used to determine the pool volume of an 18 in. decantor-type centrifuge.

Volume of frustrum of cone $= \frac{1}{3}\pi h[(R+R')^2 + \frac{1}{3}(R-R')^2]$

$R' = 5$ in.

$R = 9$ in.

$H = 22.7$ in.

$$\text{Full volume} = \frac{22.7\,\pi}{4}\left[(9+5)^2 + \frac{(9-5)^2}{3}\right] =$$

$$\frac{22.7\,\pi}{4}\left[(14)^2 + \frac{(4)^2}{3}\right] =$$

$$5.675\,\pi\,[196 + 5.3] + 5.31] = 5.675\,\pi\,(201.3) =$$

3588.9 cu in.

$$\text{Less core} = 3588.9 - \pi\,(5)^2\,(22.7) =$$

$$3588.9 - 1782.9 = 1806 \text{ cu in.}$$

$$\text{Volume of pool} = 1806 \text{ cu in.} = \frac{1806}{231} = 7.8 \text{ gal}$$

Once the effluent ports are positioned and the pool volume is known, that value is a constant. The retention time may be determined if the feed rate is known.

$$\text{Retention time} = \frac{\text{Pool vol in gal}}{\text{Feed rate in gal per min}}$$

The answer is in minutes which is usually converted to seconds to avoid the use of fractions. This is done by multiplying by 60.

Rate at which particles pass through the pool depends upon rate of feed. Degree or fineness of the separation will in turn be dependent upon the time of retention.

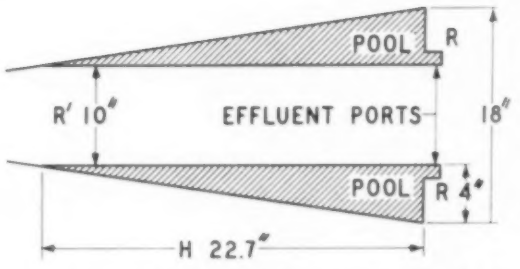


FIG. A1. **Pool volume** is dependent upon position of effluent ports.

The centrifugal force to which the particles are exposed while they are retained in the bowl may be expressed as multiples of gravity or gees. The formula for determining gees exerted by a centrifuge is:

$$\text{Gees} = (2.84)\,(10^{-5})\,(N^2R)$$

or

$$\text{Gees} = \frac{2.84\,(N^2R)}{100{,}000}$$

Wherein:

N = revolutions per minute.

R = bowl radius, in inches.

$2.84\,(10^{-5})$ = constant.

The two factors which most affect the centrifuge process, therefore, are the centrifugal force (gees) and the length of

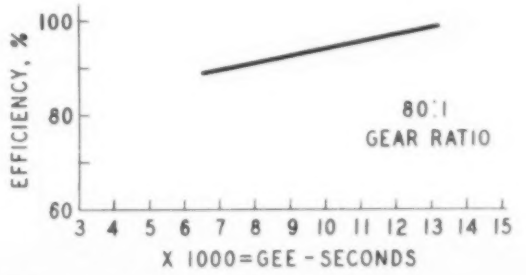


FIG. A2. **Efficiency** of barite recovery from an 18 lb mud.

time during which the particles are subjected to that force. Multiplying gees and retention time in seconds provides the term, gee-seconds.

$$\text{Gees} \times \text{retention time in seconds} = \frac{\text{gees} \times \text{pool vol} \times 60}{\text{gal per min flowing (feed rate)}}$$

or

$$\text{Gee-seconds} = \frac{\text{gees} \times 468}{\text{feed rate, gpm}}$$

Fig. A2 shows the relationship between gee-seconds and the centrifuge efficiency for maximum barite recovery from an 18 lb per gal mud.

Centrifuge Adjustments. The adjustments which can be made in order to obtain the best efficiencies on the centrifuge are:

1. Speed.
2. Volume of pool.
3. Location of feed pipe.
4. Viscosity of feed.
5. Feed rate.

Generally speaking, the following rules determine the type of separation obtained in the decanter type centrifuge.

Maximum gee-seconds = Maximum barite recovery (also retains maximum clays)

Minimum gee-seconds = Minimum barite recovery (also maximum clay removal) ★ ★ ★

THE OASIS—

A gathering spot for NOMADS

World seemed a little smaller at the February meeting of the Houston chapter of Nomads, held February 11, at the College Inn. Foreign guests at the meeting included: (front row) Miguel Tejada, YPFB, La Paz, Bolivia; Rene Najera, YPFB, La Paz; Delbert D. Lewis, Import Tool Company, Calgary, Alberta, Canada. Back row: Jack Parks, Mene Grande, Eastern Venezuela; John Newkirk and R. E. McCafferty, Amerada Petroleum Company, Hargeisa, British Somaliland; F. George Bestall, British Consul, Houston, Texas; and Fernando Halpern, formerly from Argentina, now with the Fish Engineering Company of Houston.

Nomads Meeting Dates and Secretaries

New York Chapter, first Monday, of the month, Hotel Roosevelt, New York. Executive Secretary, E. W. Hoeppner, in care of Hughes Tool Co., Room 903, 45 Rockefeller Plaza, New York 20, N. Y.

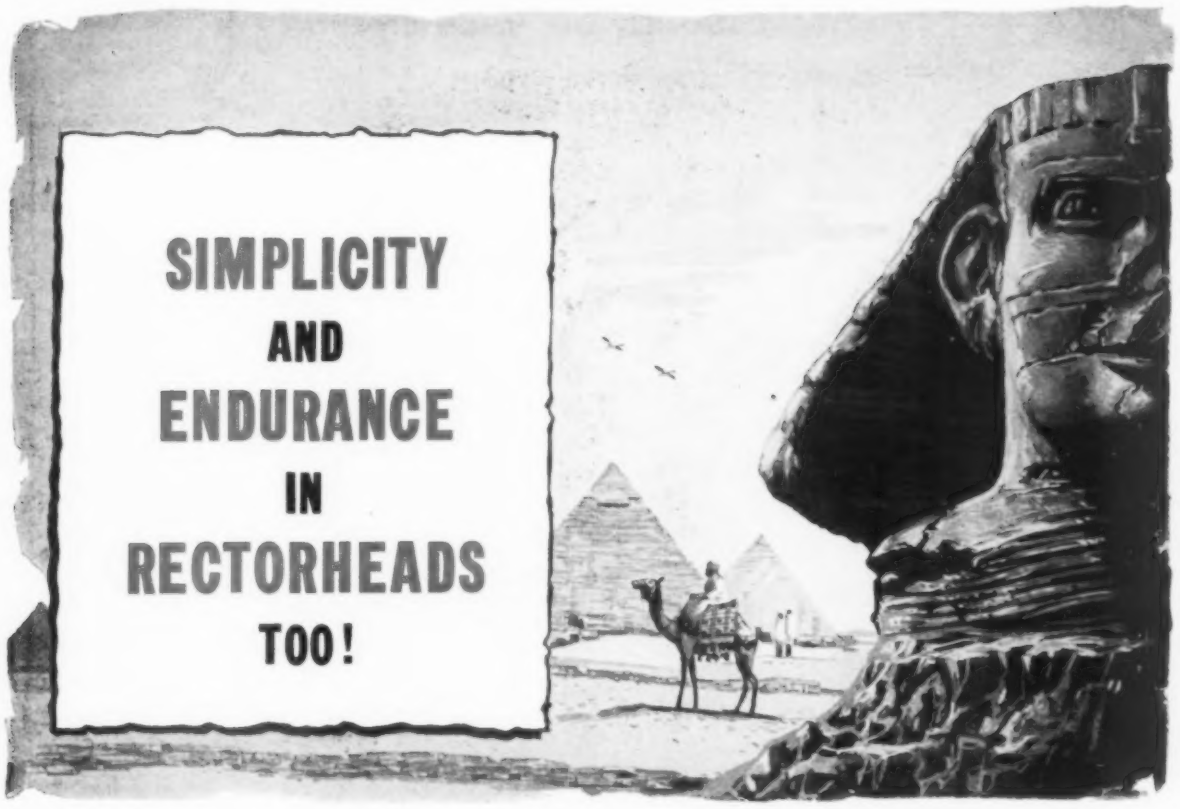
Houston Chapter, second Monday. Ye Old College Inn, Houston, Texas. Executive Secretary, Harry E. Estes, P. O. Box 18171, Houston 23, Texas.

Los Angeles Chapter, second Wednesday, Jonathan Club, Los Angeles, California. Executive Secretary, W. A. Sawdon, P. O. Box 848, Hollywood 28, Calif.

Tulsa Chapter, third Friday, Mayo Hotel. Executive Secretary, E. L. Thomas, P. O. Box 3771, Tulsa 9, Okla.

Dallas-Fort Worth Chapter, first or second Monday. Secretary, R. B. Gilmore, DeGolyer & MacNaughton, 5625 Daniels, Dallas, Texas.

An Open meeting at the Hotel Roosevelt started the New York Chapter of Nomads 1957 social season. The party was attended by approximately 140 guests and Nomads. Visitors included these shown here. Seated are: R. Emery, Halliburton Oil Well Cementing Company, Kuwait; J. Haltenberger, Cardwell Manufacturing Company, South America; L. W. Schrader, Commonwealth Oil Refining Company, and A. E. Albisten, Brown Drilling Company, Long Beach California. Standing are: E. Ferrin, Gulf Eastern Oil Company, London; O. D. Arnold, Socony Mobil Overseas; J. Bennet, Gulf Oil Company; G. Mariaca, Argos, Bolivia; P. Neiger, Switzerland; C. F. Raper, Bogata, Colombia; J. Thornton, Varel Manufacturing Company, Dallas, Texas.



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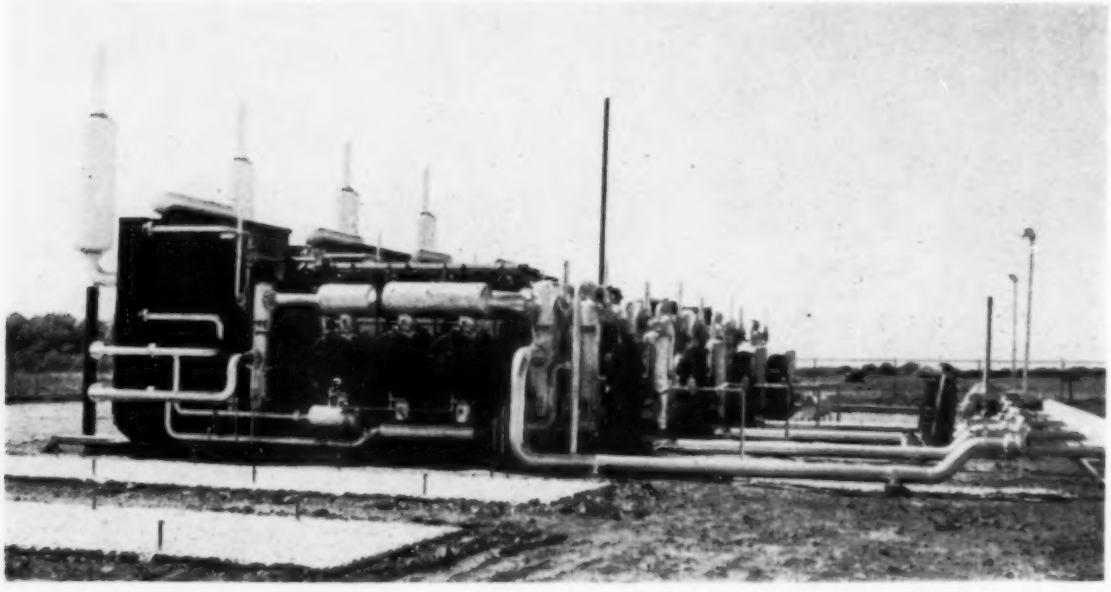
Harry E. Hester of McCullough Tool Company (right) retiring president is presented with a gavel to commemorate his service during the past year by John H. Flanagan of Johnston Testers, Inc., retiring senior regent and master of ceremonies at the Eighteenth Annual Inaugural Ball of the Los Angeles Chapter of Nomads held at the Ambassador Hotel February 9, 1957.

1957 Officers of the Los Angeles chapter of Nomads at the Eighteenth Annual Inaugural Ball held at the Ambassador Hotel on February 9, 1957. In the front row are: Ben A. Hilliard of Web Wilson Oil Tools, Inc., treasurer; William C. Brooks of Byron Jackson Tools, Inc., vice president; Robert P. Gaylord of Wagner-Morehouse, Inc., president; Tom G Martin of R. J. Eiche & Associates, secretary; W. B. Reinhold of Abegg & Reinhold Company, assistant treasurer; Harry E. Hester of McCullough Tool Company, junior regent. (Back row) H. J. Schlarb of Continental-Emsco Company, senior regent; Earl M. Daniels of Hydril Company, sergeant-at-arms; Tom R. Ashe of Globe Oil Tools Company, deputy sergeant-at-arms; Wm. (Andy) Anderson of Pacific Perforating Company, assistant secretary; John H. Flanagan of Johnston Testers, Inc., master of ceremonies.



Ideal Field Compressor Station?

This may well be the ideal field compressor station. It was erected at minimum cost; moreover, it can be expanded to meet future field needs. By the same token its horsepower can be reduced as field production dwindles. As shown, the station has no building, offices and what not, and the only advance preparations required for the installation of additional units are concrete mats similar to the ones shown at the lower left, plus of course, suction and discharge pipes tying in to the manifold.

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Thirteen gas wells in the Keller's Bay field flow into a central primary separation station on Sand Point (see map) where condensate and moisture are removed. The gas is carried through 4½ miles of 8-in. line under water to Magnolia Beach where it connects with United Gas Pipe Line Corporation's pipeline. Condensate separated from the gas is carried in a separate 4-in. line from Sand Point to the Magnolia Beach terminal. Since the gas delivered into the sales line had to buck a pressure of 800 psi, it was necessary that the delivery pressure be held constant at about 850 psi, although the demand volume may vary up to 30 MMcf per day, maximum capacity for which the system was designed.

In itself, this problem would not at first appear very difficult nor unusual. However, there were other production problems tied in with these requirements that added some complication, and which make the system unusual.

Production problem. Humble operates 10 wells in the Keller's Bay field. Three of these wells have been dually completed, and the production from each zone is handled separately. Production is carried through 2-in. flow lines from the wellhead to the primary gas separation on Sand Point. Therefore, from a design problem, the system included 13 wells, since 13 flow lines converged at the separation station. Facilities were also installed to handle two additional flow lines should the need ever arise.

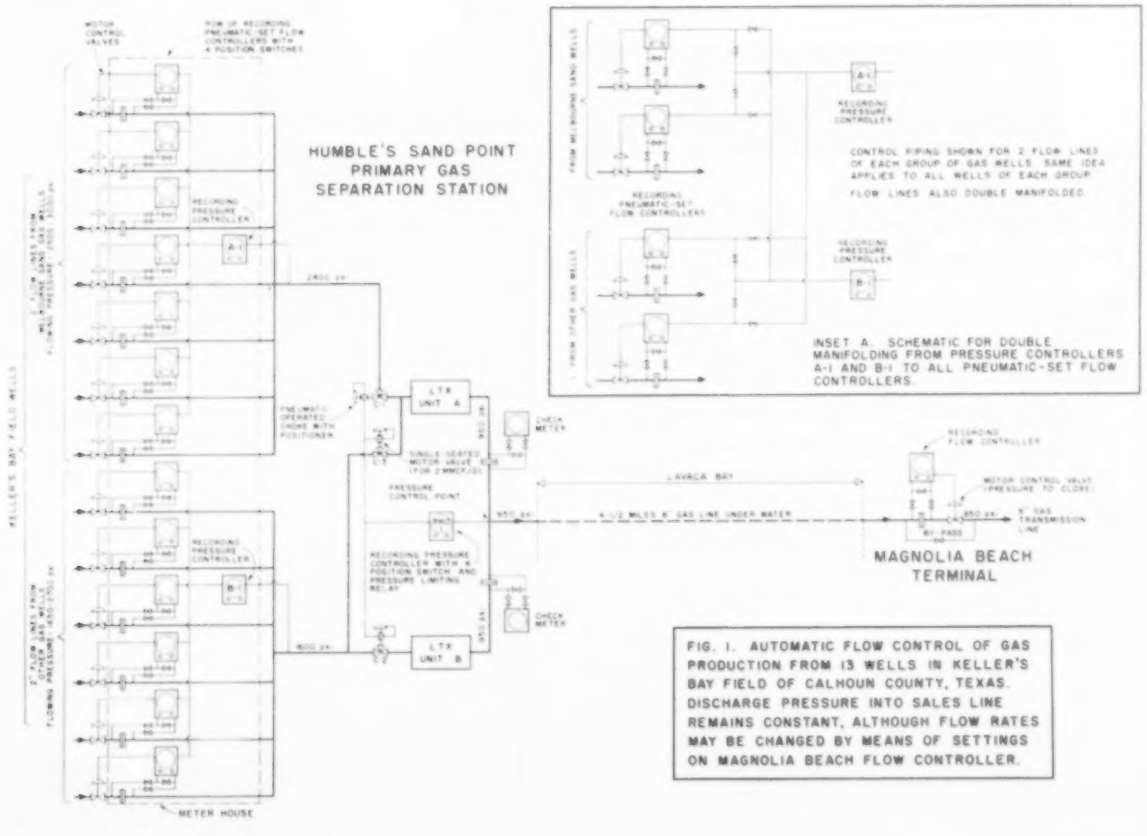
HUMBLE'S SAND POINT
PRIMARY GAS
SEPARATION STATION
LTX UNIT A
LTX UNIT B
LAVACA BAY
MAGNOLIA BEACH
TERMINAL
METER HOUSE
CONTROL PIPING SHOWN FOR 2 FLOW LINES OF EACH GROUP OF GAS WELLS. SAME IDEA APPLIES TO ALL WELLS OF EACH GROUP.
FLOW LINES ALSO DOUBLE MANIFOLDED.
INSET A. SCHEMATIC FOR DOUBLE MANIFOLDING FROM PRESSURE CONTROLLERS A-1 AND B-1 TO ALL PNEUMATIC-SET FLOW CONTROLLERS.

FIG. 1. AUTOMATIC FLOW CONTROL OF GAS PRODUCTION FROM 13 WELLS IN KELLER'S BAY FIELD OF CALHOUN COUNTY, TEXAS. DISCHARGE PRESSURE INTO SALES LINE REMAINS CONSTANT, ALTHOUGH FLOW RATES MAY BE CHANGED BY MEANS OF SETTINGS ON MAGNOLIA BEACH FLOW CONTROLLER.

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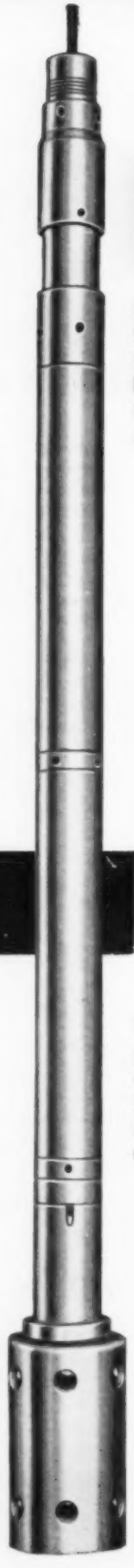

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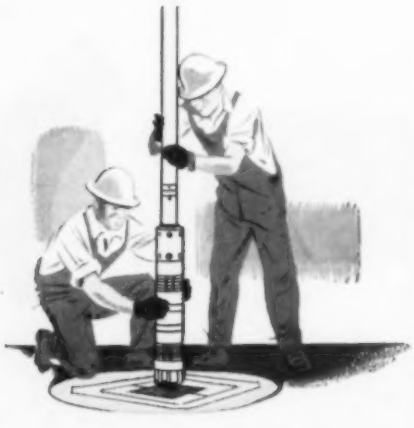

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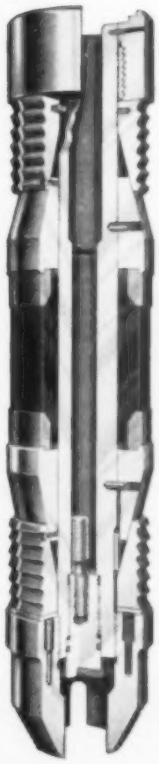

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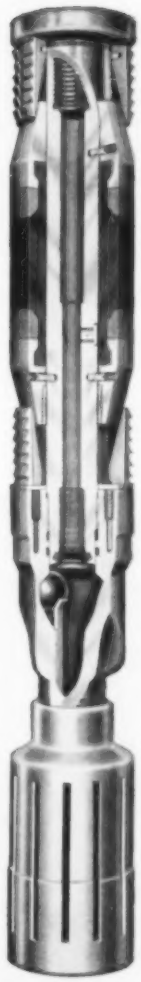

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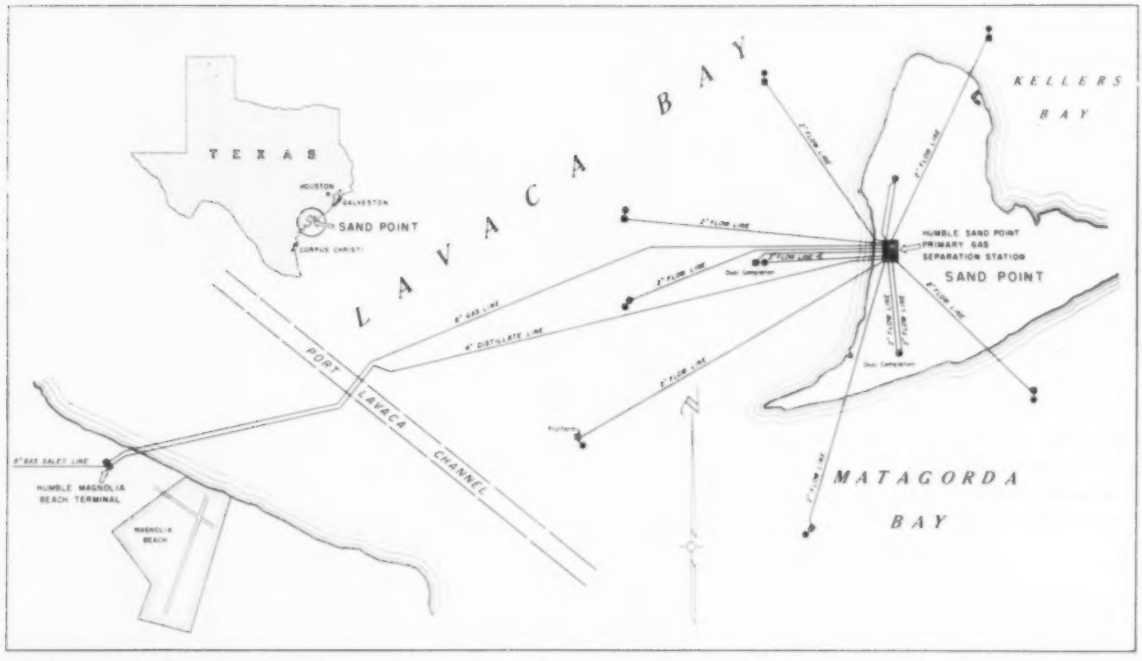


◀ FIG. 2. **Layout** of Humble's Keller's Bay gas production facilities in relation to producing wells. Primary point of control is at the Magnolia Beach terminal sales point.

Of the 13 2-in. flow lines connected to the Sand Point separation station, seven of these carry production from the Melbourne gas sand. For production reasons, it was desirable to produce these seven wells at their maximum allowable. Flowing pressures ranged from 2500 to 3000 psi.

The remaining six wells produce from gas zones at depths of 7800 ft and at 8400 ft. And, flowing pressures from these six wells varied from 1650 to 2700 psi.

Pressure and volume controls. Since it was desired to produce all seven Melbourne gas sand wells at their maximum allowable of 13 million cu ft per day, these wells were grouped into one system for control designing. In this system, it was simply a matter of reducing the flow line pressure which varied from 2500 to 3000 psi down to a common discharge header pressure of 2400 psi. These wells were permitted to flow their maximum allowable of 13 MMcf daily, although the demand for gas from all Keller's Bay gas wells might go as high as 30 MMcf per day. Gas from the Melbourne gas sand well flowed through the individual meter runs where gas volumes were recorded, then into a common header and into a low temperature extraction unit, labeled LTX Unit A in Fig. 1.

From a control standpoint, the other six gas wells were grouped together. Flow line pressures from these wells varied from 1650 to 2700 psi, and it was necessary to drop the pressure to 1600 psi into a header for this group of wells. Gas from this header flowed into a second low temperature extraction

◀ **Bay installation** for producing gas well. Wellhead for single producer at right. Platform at left supports glycol storage tank and injection equipment and water knockout unit.

▶ **Closeup of glycol storage tank** and water knockout unit on platform near wellhead for single zone gas producer.

unit, labeled LTX Unit B in Fig. 1. Here again, the primary problem was one of reducing flow from the six wells to that required to make up the difference between the 13 MMcf per day produced from the Melbourne gas sand wells and that volume demanded by the gas pipeline company.

Function of LTX units. In addition to separating condensate from the produced gas, the low temperature extraction units also separated out any moisture and glycol from the flow stream. At the flowing pressures described, hydrate formation was previously a problem. Glycol was injected at the wellhead by means of an injection pump which injected the glycol into the flow line stream above flow line pressure. Purpose of the glycol is to prevent any hydrate formation in the flow line system due to some moisture in the gas. Water knockout units were also placed at the wellhead to remove as much of the moisture as possible before the glycol was injected. It is necessary that the pumpers periodically fill the glycol injection units at the wellhead.

At the low temperature extraction unit, the glycol is recovered by means of a glycol reboiler. Dry gas passed out of the LTX unit, while recovered gas condensate flows through a 4-in. line from the Sand Point separation station to Magnolia Beach. Recently, when about 22 MMcf per day of gas flowed through the 8-in. pipeline, about 600 bbl of condensate were recovered.

Discharge of dry gas from both low temperature extraction units is into a common header at about 950 psi. This manifold ties into the 8-in. pipeline crossing the Lavaca Channel to Magnolia Beach. Through LTX Unit A, there exists a pressure drop of approximately 1450 psi, while across Unit B, about 650 psi.

Magnolia Beach controls. Termination of this production system at Magnolia Beach is a relatively simple, but important, installation. It consists primarily of a meter run, with orifice plate flanges, a recording flow controller and a motor control valve on the down stream side of the meter run. From this point, the line connects into an 8-in. gas transmission line operated by United Gas Pipe Line Corporation.

Key control point. It is from the Magnolia Beach terminal that production from all 13 gas wells described above is controlled. Because the total delivery volume of gas into United's line could be varied as required, it was necessary to be able to change the flow of gas produced from the Keller's Bay field from this point. Previously, it was necessary for the pumper to make a boat trip across the bay, which in times of inclement weather was hazardous or impossible, and change the individual well flow settings. After the new control installation, it was only necessary for the pumper to change the setting on the recording flow controller at the Magnolia Beach terminal to change the volume of gas flow into United's system.

Thirteen 2-in. flow lines converge at the Sand Point meter house. Manual valves in risers at left control flow from well and blow down to pit. Adjacent to meter house are individual flow line motor control valves. Note lines in foreground for two possible additional wells.

Double manifolding of flow lines leaving the meter house on Sand Point. Valves permit flexibility in producing any well into either of the two low temperature extraction units.

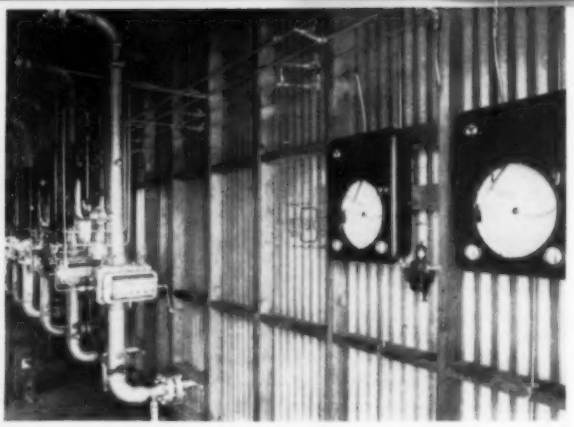
Details of Flow Control System

The entire system has been designed for a maximum flow of 30 million cu ft of gas per day. It has already been stated that seven of the 13 wells are allowed to produce at their maximum allowable flow rate of 13 MMcf per day, so long as the demand is at this rate or above it. The difference in flow rate above this maximum amount from the Melbourne gas wells is made up by the remaining six gas wells.

Here's how the overall control of flow works. Discharge of gas into United's pipeline must be at 850 psi, regardless of flow rate. The motor control valve (requires pressure to close) at Magnolia Beach regulates the rate of flow. In recent operations, rate of flow was set at 22 MMcf per day. This flow rate was established by setting the recording flow controller at the desired rate, which in turn automatically controlled the motor control valve. The production control features of the entire system were so set to allow the seven Melbourne wells to produce 13 MMcf per day (maximum allowable) with the remaining MMcf per day coming from the other six gas wells.

If the flow rate need be increased, all that is necessary is to reset the recording flow controller at Magnolia Beach. For example, if the rate of flow desired is 28 MMcf per day, the recording flow controller is set for this rate. The motor control valve opens slightly to accommodate this higher flow rate, and in

Recording pneumatic-set flow controllers on each flow line regulates flow line motor valve for desired gas production from each well, and also records volume of gas flow through vertical meter runs.



These two recording pressure controllers (A-1 and B-1 in Fig. 1) at right act as foreman over all the individual flow line controllers.

doing so, pressure in the 8-in. line across the bay is slightly lowered.

PRC-1, the recording pressure controller at Sand Point (see Fig. 1) senses this slight drop in discharge pressure, and allows the pneumatic operated choke (C-2) to open slightly (it has no effect on pneumatic operated choke C-1, since it is already opened its maximum set amount to permit 13 MMcf per day to flow from the seven Melbourne sand wells.) As more gas flows through C-2, the pressure upstream is lowered slightly, which is sensed by the recording pressure controller B-1 which is the master controller for all six wells in this group. The pressure drop is transmitted by B-1 to all recording pneumatic-set flow controllers in this group, which in turn open proportionately the motor control valves on the individual 2-in. flow lines from the six gas wells in this group. Rate of flow from this group of wells is increased to compensate for the increase in overall flow rate as demanded by the recording flow controller at Magnolia Beach. For a total flow rate of 28 MMcf per day, 13 MMcf per day come from the Melbourne sand wells and the remaining 15 MMcf per day come from the six gas wells.

Rates of flow above 28 MMcf per day. The maximum rate of flow the system can accommodate under present design is 30 MMcf per day. This rate is divided evenly between low temperature extraction unit A and B, allowing 15 MMcf per day through each unit. However, the maximum flow rate from the seven Melbourne gas sand wells is established at 13 MMcf per day, the maximum allowable. Since the maximum flow through LTX Unit B is 15 MMcf per day, and maximum allowable gas production from the seven Melbourne wells is 13 MMcf per day, any additional flow rate above 28 MMcf per day must come from the six remaining wells. This additional production is channeled through LTX Unit A, which has additional capacity.

By a unique system of controls, this is what happens. Pneumatic operated chokes C-1 and C-2 are opened to allow the maximum flow according to the limits described above. But, recording pressure controller PRC-1, sensing a demand for flow greater than the total maximum flow of 28 MMcf per day from both groups of wells causes the single-seated motor valve C-3 to open (it is sized for a maximum of 2 MMcf per day) to make up the required flow rate in order to maintain a discharge pressure of 950 psi into the 8-in. gas line from Sand Point to Magnolia Beach. The amount of gas flowing through C-3 and by-passed into LTX Unit A is that amount required above 28 MMcf per day.

Experience has indicated that it takes about 30 min reaction time for the entire control system to respond to any flow changes made at the Magnolia Beach recording flow controller. This means that when a new flow setting is made on the mainland, the motor control valves on each individual flow line respond accordingly approximately 30 min later. It is anticipated that at high rates of flow near the maximum, this reaction time would be less.

Flow limits. In order to prevent over production from any one gas well, a limiting setting can be made on the recording pneumatic-set flow controllers on each flow line. This limiting feature will not permit the motor control valve to allow more than this predetermined maximum flow from the well regardless of conditions. It also has a minimum limiting control whereby rates of flow from each well fall between certain predetermined minimum and maximum rates.

Safety control features. As in any underwater pipeline and particularly where gas is handled, provisions must be made to cope with the hazard created by a possible line break. For this 8-in. gas line extending from Sand Point to Magnolia Beach, controls were installed to close in all producing gas wells should this 8-in. line break. It works this way. The recording pressure controller PRC-1 at the Sand Point separation station is equipped with a pressure limiting relay. If the 8-in. gas line should break, the line pressure would drop suddenly. This sudden pressure drop would cause a drastic swing in the pressure sensing element which upon reaching a predetermined limit would cause pneumatic operated chokes C-1 and C-2, and the single-seated motor valve C-3 to close. Upon closing, pressure in the lines from both groups of gas wells would increase. Recording pressure controllers A-1 and B-1 would react to this sudden pressure increase, and would relay this pressure increase to each of the recording pneumatic-set flow controllers on each 2-in. flow line. The controlling pressure to these devices would cause each of the motor valves on every flow line from each well to close, thereby shutting in the field. The system can be placed back into automatic operation once the 8-in. gas line is pressured up to pre-set conditions. Although this re-set operation is automatic, it can be manual if desired.

An additional safeguard feature was made on the Magnolia Beach terminal main control system. If hydrates should form in the small pressure lines connected to either side of the orifice plate, thereby causing the differential reading to increase (which normally would indicate high flow rates), the controlling pressure to the motor control valve in the 8-in. line has been limited so the motor valve will not close completely. It is also limited so that it will not open to flow more than 30 MMcf per day for which the system was designed.

To prevent any back flow of gas from United's system into Humble's system, two 6-in. check valves were installed on the outlet of two 6-in. meter runs in United's line.

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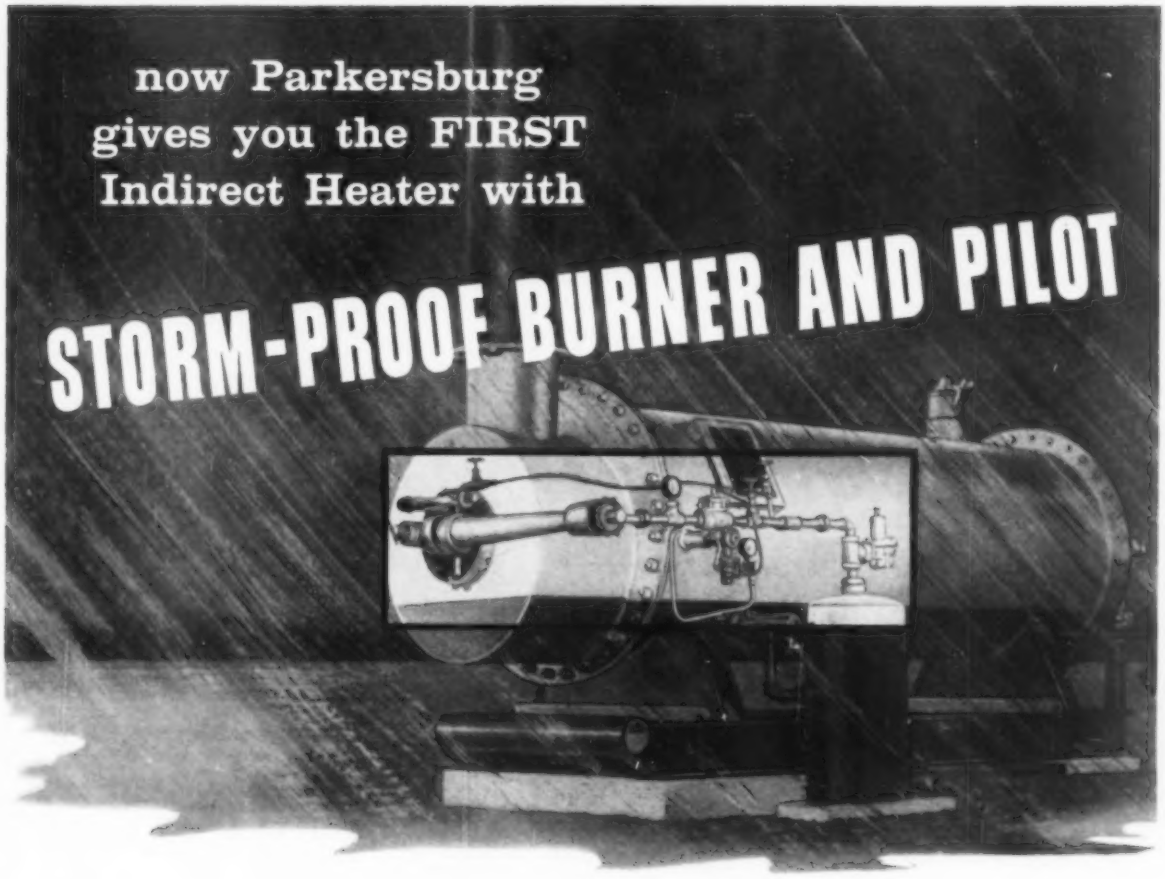

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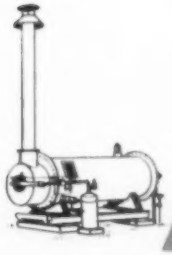

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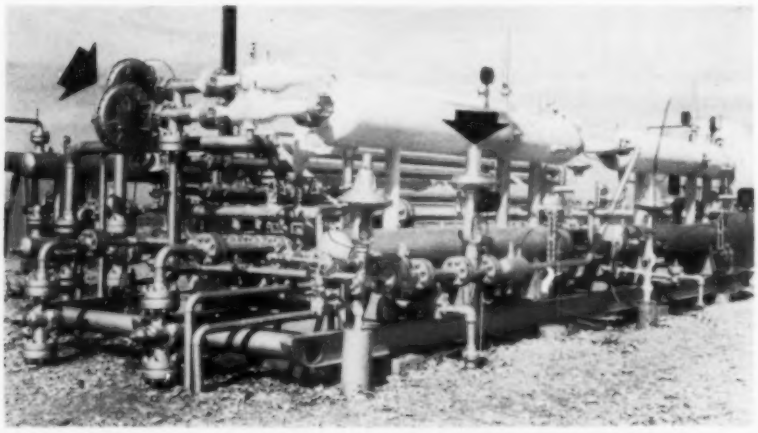
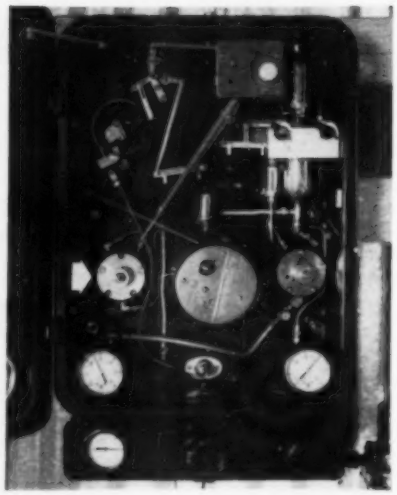
fice plates at the Magnolia Beach control point, a by-pass line was installed around the flow control to eliminate having to shut the system down just to change orifice plates.

Double check on measurement. Humble measures gas flow into United's transmission line at Magnolia Beach. This is the total gas produced from the 13 wells in Keller's Bay field. The individual recording pneumatic-set flow controllers on each flow line permit gas volume measurement from each well.

As a means of checking the volume of gas produced from each group of wells, recording orifice meters were installed on the down stream of each LTX unit and before each line ties into the 8-in. pipeline (See Fig. 1). These measurements provide a ready reference in checking flow from the Melbourne group of wells and also the remaining group of wells, to determine if flow rates have been adjusted properly. These two measurements also serve as a check against the total measurement as recorded by the meter at the Magnolia Beach terminal.

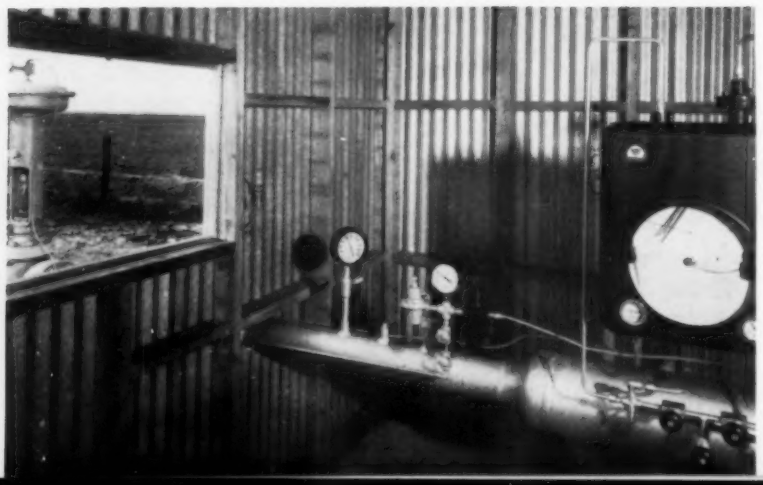


Two separate low temperature extraction systems are incorporated into equipment mounted on a single skid. Pneumatic operated chokes with positioners (left arrow) regulate flow into each LTX unit. By-pass motor valve shown by arrow near the center.



Mechanical production boss at Sand Point is this recording pressure controller, PRC-1 in diagram. Pressure limiting relay (arrow) is safeguard against any underwater pipeline breaks. It will shut all wells in if pressure in 8-in. underwater line drops below 550 psi.

Magnolia Beach terminal control system includes recording flow controller, right, and motor control valve, outside meter house window. Gas flow rate from all Keller's Bay wells is controlled by settings on this flow controller.



Double Manifolding of Controls and Gas Flow

In addition to the control of gas flow from each of two well groups (seven Melbourne sand gas wells and six remaining gas wells), provisions were incorporated in the installation for double manifolding both control pressure lines and gas flow lines. A schematic of the pressure control lines is shown in Inset A of Fig. 1. Although only two wells from each group are shown in this diagram, the same idea of double manifolding applies to all wells in each group. Gas flow lines were similarly double manifolded.

Purpose of dual manifold. It is envisioned that somewhere down the road during the productive life of Keller's Bay field, some of the gas wells in each of the two groups might change their producing characteristics, especially in flowing pressure. Should any of the wells in the Melbourne sand group drop in flowing pressure below the discharge manifold pressure (upstream of LTX Unit A), that particular well could be transferred easily over to the other group, both in controls and in flow.

By means of the double manifold system it is also possible to switch any of the wells in the six well group into the Melbourne sand group, if production conditions made it necessary. Here, too, both pressure controls and flow of gas could easily be switched over by opening and closing off appropriate valves in each system.

By such arrangement in the original installation, extreme flexibility in both flow and control was provided to cope with any production condition which might arise during the life of the field.

A step ahead. Although there is nothing revolutionary in this gas production control hookup, it does represent an approach to coping with a complicated gas production problem and provide automatic operations by pneumatic means. Such a system has insured continuous production when personnel could not reach controls in the field, and undoubtedly this type of control system will find increased application particularly in offshore gas well production where conditions are somewhat similar.

Acknowledgment

Editors of *The Petroleum Engineer* are grateful to Humble Oil & Refining Company for data and maps regarding this installation and for permission to publish this discussion; to Louis Hickman of Wescott & Greis, Inc., division of the American Meter Company, Inc., Garland, Texas, for data on the control system. ★ ★ ★

NEW DEPTH MARK for Oklahoma production was established in mid-February through British American Oil Producing Company's development of the Knox pool in Grady County. New record holder is British-American's No. 1 Reed, which flowed at the rate of 3,400,000 cu ft of gas per day on a 5-hour drillstem test from perforations in the Third Bromide sand at 15,575-635 ft. Condensate on this test gaged 143.7 bbl per million cubic feet of gas. Flow pressure on the test increased from 4635 to 5960 psi, with shutin pressure of 8000 psi after 4 hours, 45 minutes; hydrostatic pressure was 12,150 psi. Big Chief Drilling Company drilled the well, which was bottomed at 15,770 ft. Casing was set at 15,748 ft. Like the No. 2 Harrison, the Reed well was a directional hole.

British-American's Carter-Knox Bromide field is... Oklahoma's Deepest Production

Major gas field in the making below 15,000 ft. State's only true retrograde condensate reservoir to date

Glenn M. Stearns
Chief Engineer,
The British-American Oil Producing Company,
Dallas, Texas

ON February 14, 1956, The British-American Oil Producing Company and The Ohio Oil Company completed Oklahoma's deepest producer at 15,310 ft in the Bromide sand reservoir of the Carter-Knox field where shallow production was first discovered in 1924. The well, Harrison No. 2, was officially potentialled at 31 million cu ft per day, and since has produced at an average rate of about seven MMCF per day. The field extends across the county lines between Grady and Stephens counties, and is located about 30 miles west of Pauls Valley and about 30 miles southeast of Chickasha as shown on the map of Fig. 1.

First production on the Carter-Knox structure was discovered more than 30 years ago. Over 500 "shallow" wells have been drilled on the structure to test and produce from Permian and Pennsylvanian formations ranging in depth from about 1700-1800 ft. AIME statistics indicate that about 400 wells were still producing from these upper zones on January 1, 1955. These wells produce mainly from the Permian sands, but several wells are completed in the Hoxbar, Deese, and Springer of Pennsylvanian age.

For many years there had been a strong belief on the part of geologists that the deeper Simpson sands of Ordovician age offered strong prospects of being productive. Consequently, over a

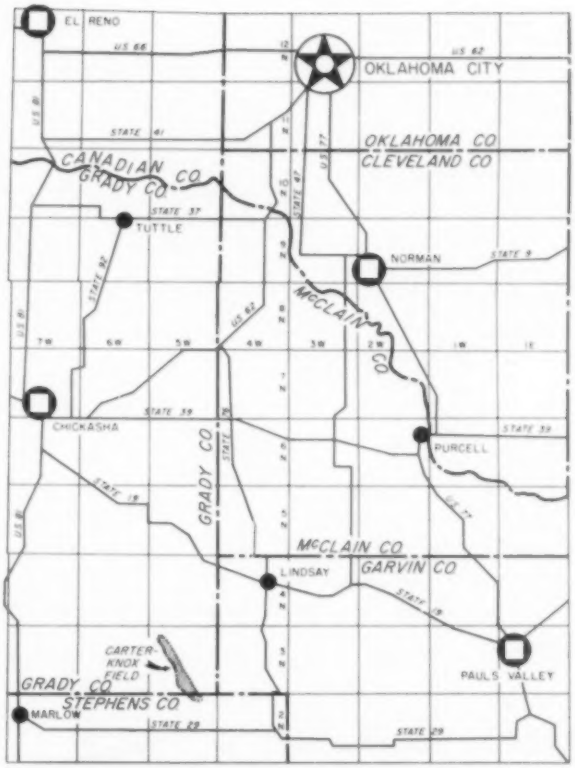


FIG. 1. **Gas production below 15,000 ft** was discovered last year in 30-year-old Carter-Knox field some 60 miles south and east of Oklahoma City and 30 miles west of Pauls Valley.

period of several years about three attempts were made to drill to the Simpson. However, all of these efforts were unsuccessful because of hole conditions and drilling difficulties that led to costly fishing jobs and ultimate abandonment before reaching the objective.

On June 14, 1955, British-American commenced drilling the Harrison No. 2 well. This well was drilled at B-A's sole cost and expense on acreage formerly owned by Ohio Oil. In exchange for drilling the well B-A received a one-half interest in the deep rights under a block of Ohio leases.

At the time Harrison No. 2 was started it was estimated that all Simpson sands could be penetrated by drilling to a depth of 13,500 ft. These untested Simpson sands included the First Bromide, Second Bromide, Third Bromide, McLish and Oil Creek. All of these sands were thought to have excellent productive possibilities at this location. At completion of Harrison No. 2, only the bromide sands had been penetrated at a total depth of 15,310 ft. The error in predicting depth was caused by the fact that the Mississippian Caney shale section was repeated four or five times due to thrust faulting. This caused an excess in thickness of nearly 2000 ft of the Springer and Caney shale at the crest of the structure. Repetition of the Caney section is evident in the cross-section, Fig. 2.

The Harrison No. 2 well was completed February 14, 1956, 244 days after the commencement date. Log data revealed that there was no sand development in the First Bromide. The Second and Third Bromide sands were found to be productive of gas condensate and the well was completed in open hole opposite the Third Bromide from 15,250-15,310 ft.

Geologic Structure

Based upon subsurface data obtained from drilling the Harrison No. 2 well and earlier shallow wells, combined with seismic data obtained after completion of the Harrison No. 2 well, the structural contour on top of the Second Bromide sand at Carter-Knox is estimated to be according to the map shown on Fig. 3. This is an elongated anticline trending in a northwest-southeast direction with a major fault forming the northeast boundary of the structure. A smaller cross-fault is thought to form the northwest boundary of the reservoir.

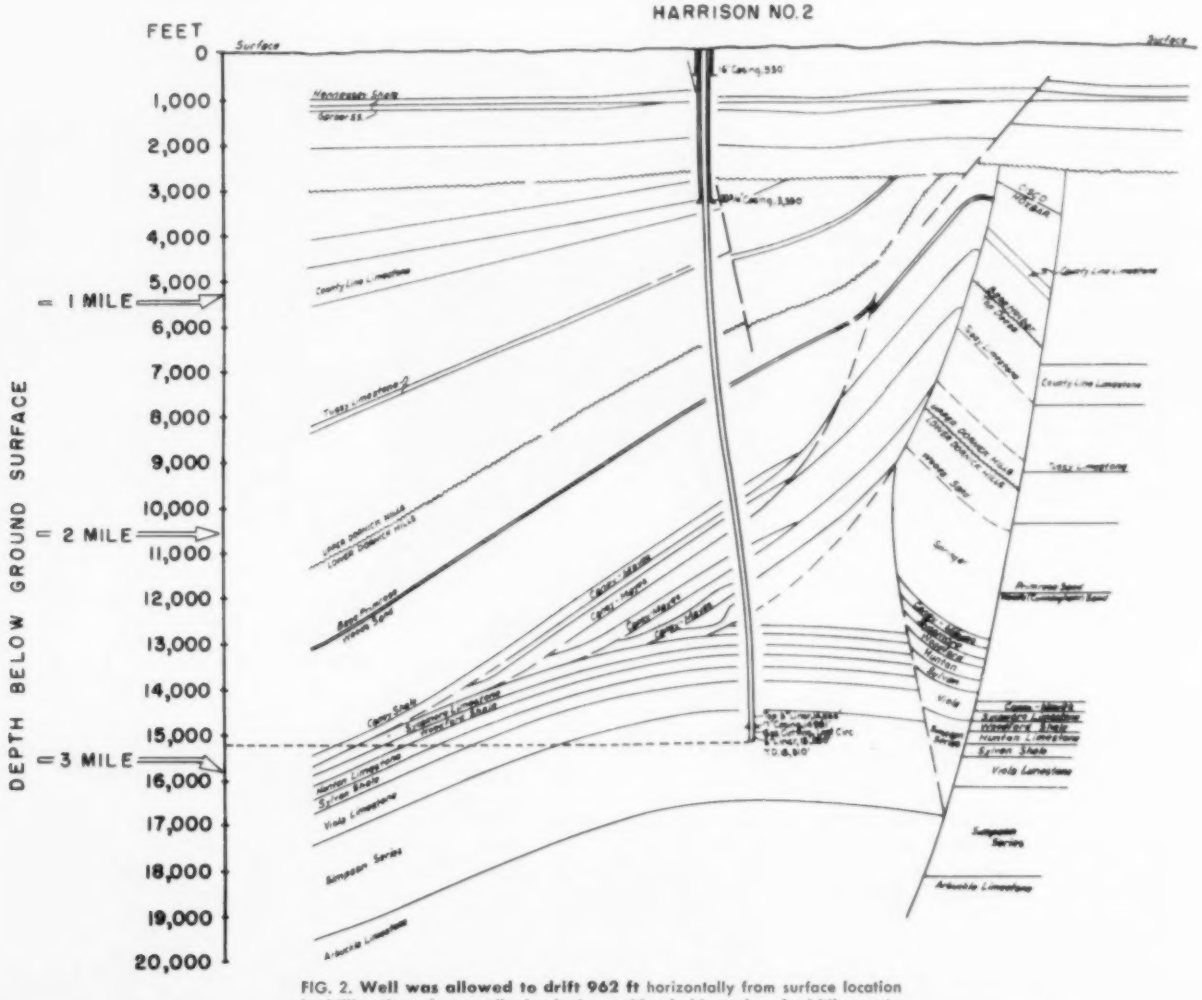


FIG. 2. **Well was allowed to drift 962 ft** horizontally from surface location in drilling through steep dipping beds, resulting in big savings in drilling costs.

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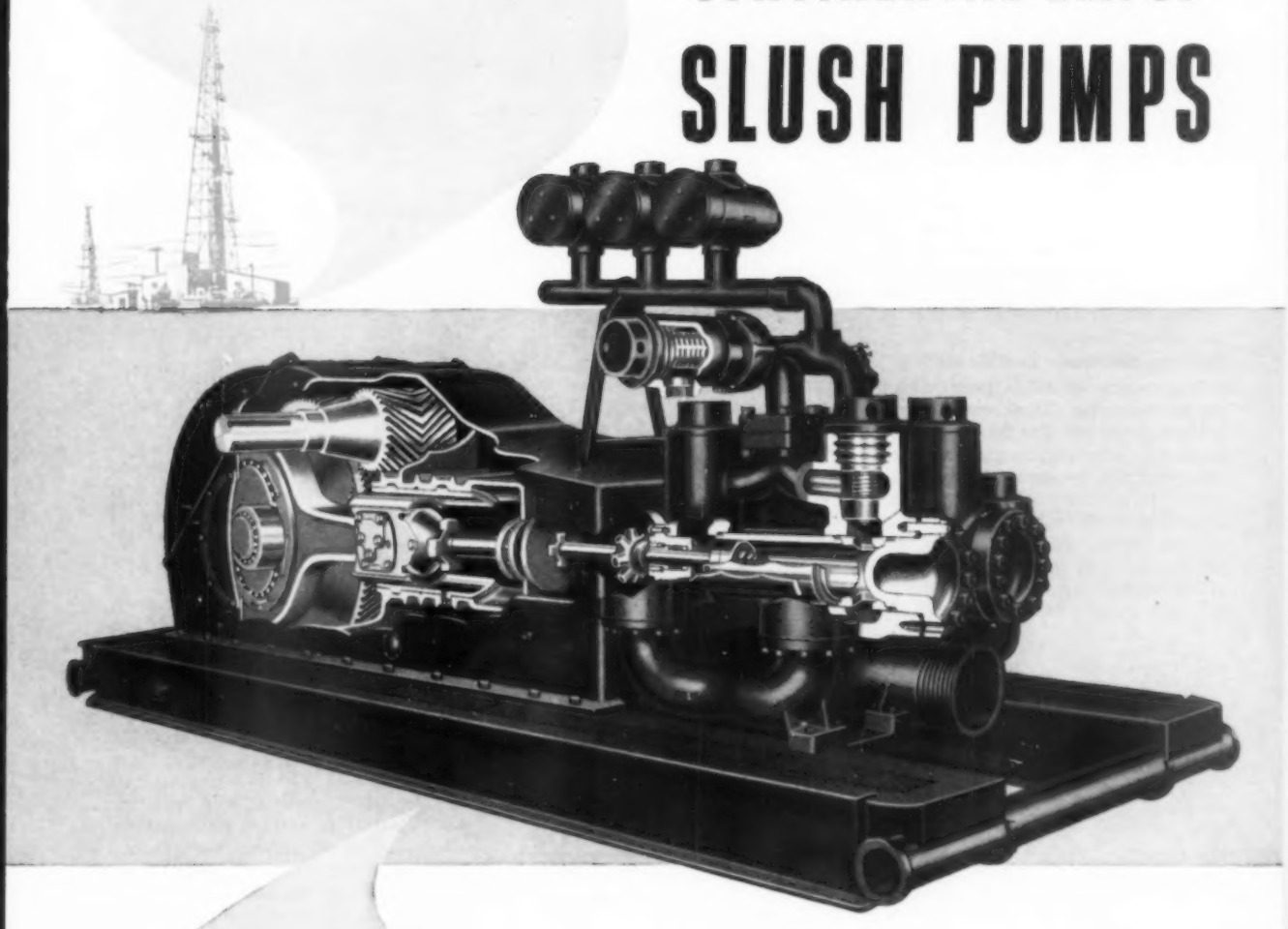

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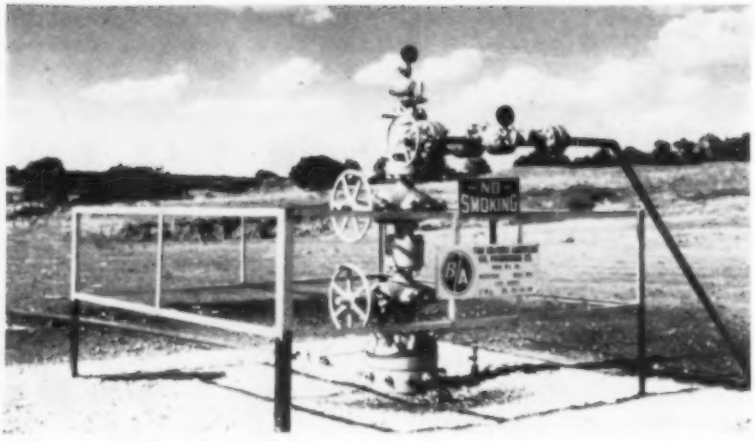
At present, there is no way of determining the structural contour that will represent the field limits. However, it was assumed that this limit would be represented by the 16,000-ft contour and this datum was the basis on which the Oklahoma Corporation Commission established an area for spacing. This spaced area is represented by the heavy blocked line shown on Fig. 3.

The Harrison No. 2 well is located in Section 29, T-3-N, R-5-W. As indicated on the map of Fig. 3, the bottom-hole location is approximately 962 ft northeast of the surface location.

Fig. 2 shows a cross-section of the Carter-Knox structure approximately at right angles to the anticlinal axis through the Harrison No. 2 well. Note that the Caney shale section is indicated to be repeated at least four times at the location of this well. This is interpreted to be the result of thrust-faulting in the lower part of the Pennsylvania and the upper part of the Mississippi.



Completed well head assembly of the Harrison No. 2, deep gas discovery of the Carter-Knox field showing high pressure tree to handle high flowing pressures.

Drilling Methods and Costs

In planning the drilling program for the Harrison No. 2 well, two features were incorporated for the purpose of promoting a significant saving in drilling cost. These two features related to:

1. Placement of well location so as to take advantage of the natural drift while drilling and revision of the normal requirements regarding hole deviation.
2. Use of the rate-of-penetration drilling contract.

With regard to the first of these features, B-A's previous experience with slant hole drilling in highly dipping formations in the Rocky Mountain area indicated that drilling rates could be increased by allowing the hole to drift off vertical rather than attempting to keep the course of the well bore within 3 or 5 deg from vertical, as is the normal practice.

At that time it was estimated that the natural drift of the bore hole would be up-dip from the surface location in a northeasterly direction a distance of approximately 1000 ft. Therefore the surface location was moved 1000 ft down-dip from the point vertically above where the hole was to be bottomed. Actually these predictions were quite accurate because the hole was finally bottomed 962 ft northeast of the surface location, which point was only 88 ft west and 97 ft north of the ideal target point. As a result, it was possible to carry increased weight on the bit and make better progress than if it had been necessary to control the course of the well bore within limits normally used. The only requirements in the drilling contract with regard to deviation from vertical were that the hole not be off vertical more than 1 deg per 1000 ft of depth and that the rate of change not exceed 1½ deg in any 100 ft of hole drilled.

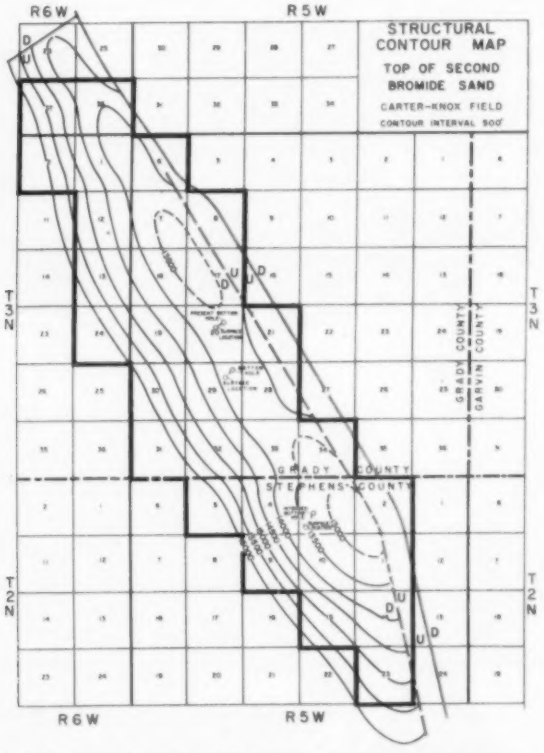


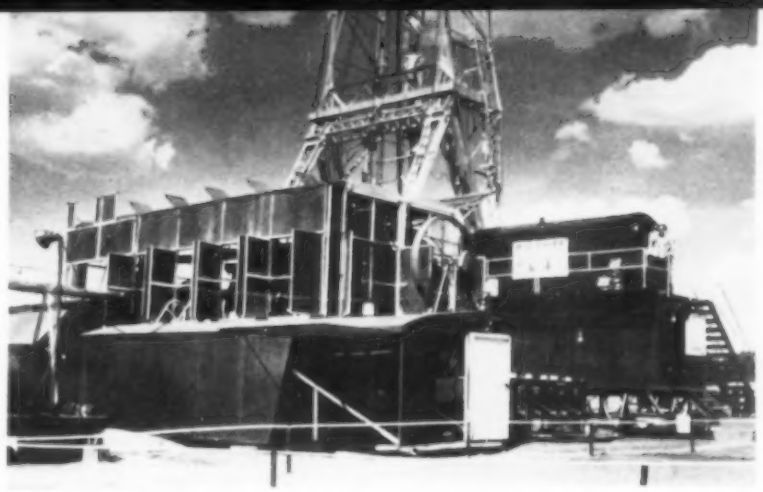
FIG. 3. **Surface and bottom-hole locations** of three Bromide sand wells in the Carter-Knox field. Two have been completed, a third is nearing completion, two more are drilling.

Rate-of-Penetration Contract

The second feature of the drilling program, already mentioned as an economy measure, involved the use of what is termed the rate-of-penetration contract. This type of contract represents a basis for paying the contractor a bonus for making good progress in drilling the well. Before drilling starts, the contractor and the oil producer arrive at an estimated drilling time to a given depth. They also agree on the average income per day that the contractor should obtain for his rig and crew with normal profit. An agreement is then made whereby the operator will pay the contractor at that rate per day which will give him a suitable profit if

he drills the well in the agreed time. If he makes better time, he is paid more per day, but the result is that the operator receives his well for less dollars per foot. On the other hand if the contractor uses excessive time in drilling the well, he is paid less per day for his rig down to a point of no profit.

The main effect is that the contractor has an incentive to make better time in drilling a well, but at the same time tends to split his extra profit with the operator. Usually the effect is that this contract prevents the contractor from adding on additional safety margin to take care of unforeseen difficulties in a footage contract.



Giant power rig of Big Chief Drilling Company, Oklahoma City, that took the rate-of-penetration contract and drilled the discovery well.

Drilling Problems

The initial bottom-hole pressure in the Bromide sands was approximately 9400 psi. This reservoir pressure requires a mud weight of 13.4 lb per gal to keep the well under control. Also the mud could not be much heavier because some of the zones in the Springer section will take mud and cause difficulty from lost circulation and possibly stuck drill pipe. Of course, loss of circulation could also lower the mud column to the point of allowing the lower zone to blow out.

To reach the Bromide reservoir, it was necessary to drill through long shale sections. Through a portion of the Lower Pennsylvania and Upper Mississippi about 5000 ft of incompetent shale was penetrated. This required close attention to mud characteristics to prevent excessive caving and stuck drill pipe. Drilling mud cost on the Harrison No. 2 well was approximately $153,000.

Of course, the cost of drilling this well was greatly influenced by the depth. At greater depths the percentage of total time that can be spent actually drilling or rotating becomes less. At 15,000 ft, approximately 12 hours are required to make a trip with the drill string. Also, older formations geologically are in general harder, and cause bits to wear out more quickly and to cut fewer feet of hole. Greater depths also require a greater length of time for placement of cement, and the high bottom-hole temperature make the cementing operation more difficult. Actually in cementing a 15,000-ft string of casing, there is not much leeway for unexpected delay which may cause the cement to set prematurely and such an occurrence can be very expensive. A pozzolin-type cement was used to resist contamination effects and high temperatures.

Casing program. The casing program on the Harrison No. 2 consisted of 520 ft of 16-in. surface casing, 3387 ft of 10¾-in., 14,931 ft of 7-in., and 585 ft of 5-in. liner.

Field conditions now indicate the necessity for a longer intermediate string and possibly a full-length production string to replace the liner. For the average future well approximately 120 ft of 20-in. conductor pipe, 3200 ft of 13⅜-in. surface casing, 13,200 ft of 9⅝-in. intermediate string and 15,300 ft of 5½-in. will be used.

Well costs. Table I indicates a general summary of the actual cost of the Harrison No. 2 well. Very little trouble was encountered in drilling the well. Taking into account additional hazards that may be encountered on future wells and also including additional depth and a more elaborate casing program, it is estimated that the average future well will cost approximately $1,070,000. Even this figure does not

TABLE I—Cost of Drilling and Equipping Harrison No. 2 Simpson Discovery Well at Carter-Knox.

Drilling	$644,716
Producing Equipment	26,715
Tank Battery	25,544
Low Temperature Separation Unit	67,799
Miscellaneous	462
TOTAL Investment Cost for Producing Well	$764,236

High pressure lease equipment, including low temperature extraction unit and stabilizing towers, handle gas and condensate for Harrison No. 2 well. Condensate is stored in 10 stock tanks at right.

include the cost of lease acquisition and seismic exploration work.

Characteristics of Reservoir Rock and Fluids

Core analyses indicate that the porosity and permeability of the Bromide sands in this field are surprisingly low. Average permeability for the net pay section was determined to be 4.18 md. Average porosity was measured as approximately 5 percent. The net pay thickness of the Second and Third Bromides was estimated, using micrologs, at 90 ft out of the gross pay section of over 200 ft. In spite of the very low permeability, the Bromide reservoir has a very high productivity. This is explained by the fact that fractures exist in the reservoir, and even though measurements on the rock matrix indicated a very low permeability, the fluid transmitting capacity of the exposed section is very high because of the presence of fractures.

Laboratory tests proved that the hydrocarbon material produced by the well is entirely in the gaseous phase underground. The reservoir is of the retrograde condensate type, i.e., upon lowering the pressure, some of the gaseous material condenses and the produced stream in the surface separation equipment is a mixture of liquid and gas. The initial state potential test on the Harrison No. 2 well showed a deliverability of 31 MMCF gas per day. Condensate content of about 162 bbl per million. As stated before, the initial reservoir pressure was 9408 psi and laboratory tests show that the dew point pressure was 5600 psi.

Production methods. Since early in 1956, Harrison No. 2 has been producing at a rate of approximately 7 MMCF of gas per day. Gas is being sold to Warren Petroleum Corporation for processing and the residue gas goes to the Public Service Company of Oklahoma for use in generating electric power. Because of the hazardous conditions attendant to the high pressures, field personnel are present at the well around the clock. Also, there is a strong possibility that this gas condensate material will be severely corrosive. This has been the case in similar wells in the Gulf Coast area.

It is estimated that the operating cost for an average well in this area will amount to $2,167 per month. All indications are that this reservoir will be a good candidate for pressure maintenance or recycling. Fortunately there is a margin of about 3800 psi between original reservoir pressure and the dew point pressure. Pressure decline has been rather slight so far. Therefore, it appears that several months of performance can be observed before a decision is required concerning the nature of any pressure maintenance project. Installation of such a project will depend upon the balance between the prospective profits and the cost of installing and operating the project.

Well spacing. Fortunately the Oklahoma Corporation Commission has granted 640-acre spacing in this field. This sort of spacing program is desirable in order to permit sufficient profit to an operator to justify drilling these expensive wells. With the favorable spacing program that is now in effect, it appears that Carter-Knox Bromide may develop into one of the major fields in the state of Oklahoma. Actually, it is the only true retrograde condensate reservoir in the state. ★ ★ ★

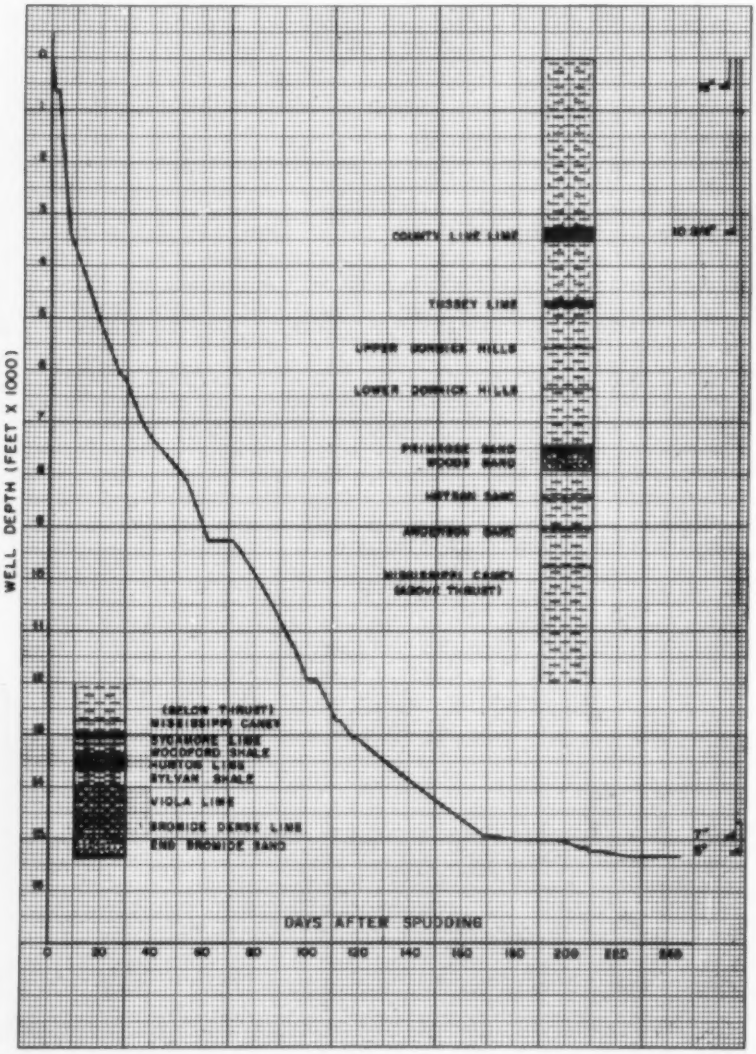


FIG. 4. **Drilling time log** of British-American's Harrison No. 2, compared alongside casing program and geological formations.

The Author

Glenn M. Stearns is chief engineer for the British-American Oil Producing Company with headquarters in Dallas, Texas. A native of Wheeler County, Texas, he received his BA degree from Oklahoma Baptist University at Shawnee, Oklahoma, in 1933, and his BS degree in petroleum engineering from the University of Oklahoma in 1936. He was district engineer for Cities Service Oil Company in western Kansas for two years until 1938 after which he accepted an assistant professorship in petroleum engineering at OU. In mid 1947, he joined Stanolind Oil and Gas Company as a development superintendent expediting secondary recovery activities. He has long been a member of the API and served on many of its committees, as well as a member of AIME.

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P 432.

15,400 FT OF SLICK CASING

Wm. T. Burton Industries runs record length of 9⅝-in. casing in 12 hours

Burton drilling barge in Lake Palourde, near Morgan City, Louisiana, that ran record string of casing into the company's three-mile deep well. Drilling is expected to continue.

LONGEST string of 9⅝-in. casing ever set during a drilling operation has been set by the Wm. T. Burton Industries, Inc., on its State Lease 2833, No. 1 well in Lake Palourde near Morgan City, Louisiana, to a depth of 15,400 ft.

String was run in just 12 hours, partially credited to "slicked-up" mud in the hole — a mixture of drilling mud graphite with 13.5 lb per gal mud.

Rack weight of the casing was 719,000 lb.

A Burton drilling barge was used to drill the hole and run the record string.

Fast Time

Total time consumed in setting the record string, from beginning to end, was 28 hours. This included 8 hours spent laying down drill pipe, 1 hour breaking down drill collars, and 12 hours running casing. Before casing was run, 7 hours was spent re-rigging and replacing rotary table.

On bottom of the 9⅝-in. casing was a combination float and guide shoe.

Mud Properties at Time Casing Set

Mud weight	13.5 lb per gal
Funnel viscosity	48 sec
Stormer viscosity	59 cps
Gel strength	0 — 0
pH	12.5+
Water loss	1.6 cc
Cakes	1/35 in.
P filter	8.0 cc filtrate
P alk filtrate — 8.0 cc	
Chloride	1600 ppm
P alk. mud	49.0 cc
Solids content	24½% by volume
Oil content	10½% by volume
Lime content	11.0 lb per bbl
Graphite content	4.0 lb per bbl

Float collar was located one joint up and another collar two joints above the shoe.

In running casing, 100,000 lb were lost in the first 4000 ft. With the last 4000 ft of the string floated in, the highest indicated weight of the casing in the hole was 490,000 lb. After casing got to bottom, it took 1 hour and 45 minutes to fill last 4000 ft with mud.

Smooth Job

As a precaution against sticking the casing, 4 lb per bbl of drilling mud graphite was added to the mud system prior to running casing. After casing reached bottom, circulation was broken with only 750 psi. For 2½ to 3 hours prior to cementing, including time spent mixing cement, mud was circulated at a pressure of 500 psi with no lost circulation.

Grady Roper, executive vice president and general manager for Wm. T. Burton and owner of Grady Roper Drilling Contractor, remarked that the mud was in such good shape it was never necessary to by-pass the shale shaker. Roper gives "the most beautiful and best mud I have ever seen" much credit for the success of the operation.

Set Up

Some 2500 sacks of pozzalan-based bulk cement was used to cement the string. Mixing time was 1 hour and 10 minutes; pumping took 1 hour and 30 minutes. Pump-down pressure, supplied by rig pumps and cementers' pumps, was 1250 psi. When plug hit bottom, a seal was obtained with a pressure of 2000 psi. Then the pressure was bled off and the plug held. Cement was left for 36 hours.

During cementing 450,000 lb of casing was hanging on the block.

Casing was set by a 6-man crew using power tongs under direction of Frank Mosing. Burton crew worked on the rack under direction of Grady Roper and Claude Hoffpauir, assistant general manager and drilling superintendent for Burton. Other Burton personnel on the job included Willey Beck, mechanic and pusher and Dalbert Burleigh, transportation superintendent.

At present, drilling is stopped while a new gas line is brought in for new fuel supply. When drilling resumes, how deep will the well go? No one at the Burton organization, either on the well or at the firm's main office at Sulphur, Louisiana, is sure. One thing is sure: With its 9⅝-in. casing set to a record depth of 15,400 ft, it is in a position to go as deep as any well yet drilled . . . and deeper.

Acknowledgment

Photograph, mud program, casing schedule and general information are presented through the courtesy of Magnet Cove Barium Corporation.

Casing Schedule

JOINTS (From the Bottom)	SPECIFICATIONS	WEIGHT IN LB	LENGTH IN FT
118	9⅝" N-80 lb per ft Long Thread and collars	192,030.76	4,039.06 (Not including thread)
115	9⅝" N-80 43.5 lb per ft Long T and C	265,273.87	6,036.90 (Not including thread)
22	9⅝" N-80 47 lb per ft Long T and C	32,996.82	693.36 (Not including thread)
24	9⅝" N-80 53 lb per ft Long T and C	50,895.37	950.79
41	9⅝" N-80 43.5 lb per ft Integrated joint, hardened end, short thread	73,877.36	1,686.80 (Not including thread)
11	9⅝" N-80 47 lb per ft Integrated joint, hardened end, short thread	27,200.31	574.79
34	9⅝" N-80 53.5 lb per ft Integrated joint, hardened end, short thread	77,176.96	1,433.00

Total length of string, including threads 15,577 ft.
Overall drillers' string was 15,419.39 ft, with 10.39 ft hanging above the rotary.
Floating equipment measured 5.18 ft of 53.50 lb per ft strength.

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"Carrot-Free" Jet Perforating Developed by McCullough Six Years Ago

Slug-free Glass Jet shaped charges were introduced to the oil industry six years ago. In all these years of use in thousands of wells, and through hundreds of competitive tests conducted or witnessed by oil company engineers, there has never been evidence that carrots or slugs were formed when McCullough Glass Jet Units were fired.

Throughout the years, "carrot-free" jet penetration has been one of McCullough's major advantages. Yet the fact was hard for oil men to believe, because *all other* jet perforating processes did form carrots. Their presence was accepted as an unwanted but natural consequence of the process.

THEN CAME FINAL PROOF—proof so final that many of the other perforating companies were forced to the need of improving their processes. In a recent major penetration research project, McCullough Tool Company was the only service company that consistently shot clean, "carrot-free" jet holes. Others participating consistently produced slugs or carrots that partially or completely plugged the perforations.

You'll hear a lot of sales talk—see a lot of claims about new "carrot-free" jet perforating methods as a result of these tests—but remember, McCullough Glass Jet Units are the *only* shaped charges that have been actually *proved* "junk-free" through six years of satisfactory service.

In addition to being "carrot-free" McCullough Glass Jet Perforators are almost 100% junk free from other sources. The Glass Jet Units completely disintegrate when fired—no metal, rubber or synthetic fragments to plug perforations or leave junk in the hole. Also, after firing the Steel Strip Carrier is removed from the hole intact.

Glass Jets Perforate 7 Zones in 200′ of Formation in 2 Runs

Powerful, Junk-Free Glass Jets in Steel Strip Carriers Shoot 7 Zones for 970 B/D—Lost Production Regained by Use of McCullough Combination Services.

Drilled in 1946, this well was completed by setting 7″ O.D. casing on top of the pay zone, drilling into the pay with a 6½″ bit and producing from open hole. Recently gas broke into the hole from an adjacent gas injection well and almost entirely killed production.

Operator decided to cement a 5″ O.D. liner in open hole below the 7″ casing, but, while attempting this, they discovered they had a bad place in the 7″ at 2500′. A 5⅜″ O.D. McCullough Bridge Plug was set below the bad spot and the hole was squeezed off. The Bridge Plug was drilled out and a combination string of 5½″ casing with 5″ on the bottom was run out into the open hole below the original casing.

A McCullough Radiation Well Log was run, obtaining Gamma Ray and Neutron Curves and a simultaneous collar log. The log revealed seven productive zones spread over 200′ of formation—a total of 150′ of pay zones to be perforated.

Two 100′ Steel Strip Carriers were loaded with Standard Casing Glass Jets, leaving blank sections to straddle unwanted zones, and the 7 pay zones were shot with a total of 600 shots.

The well came in making over 1100 barrels and has settled to a steady production of 970 barrels of oil per day—slightly more than it had originally produced from the open hole completion. The operator was well pleased with the fine results obtained with McCullough Services and, because of bonus production, is programming several wells to be re-worked in the same fashion.

Here is the ONLY jet perforating charge that has been PROVED "carrot-free" and "junk-free" by six years of actual field use—the McCullough Glass Jet Unit.

The versatility of Glass Jet Perforators with Steel Strip Carriers is well-known—the oil industry has been using them successfully for the past six years. The advantage of being able to run extra long Steel Strip Carriers, to straddle unwanted intervals and perforate any number of pay zones in a single run has been proved by hundreds of jobs like the above. Add to this the fact that McCullough is the *only* service company able to offer *proved* carrot-free, junk-free perforating and you've got a perforating value that can't be topped—always specify McCullough Glass Jet Perforators.

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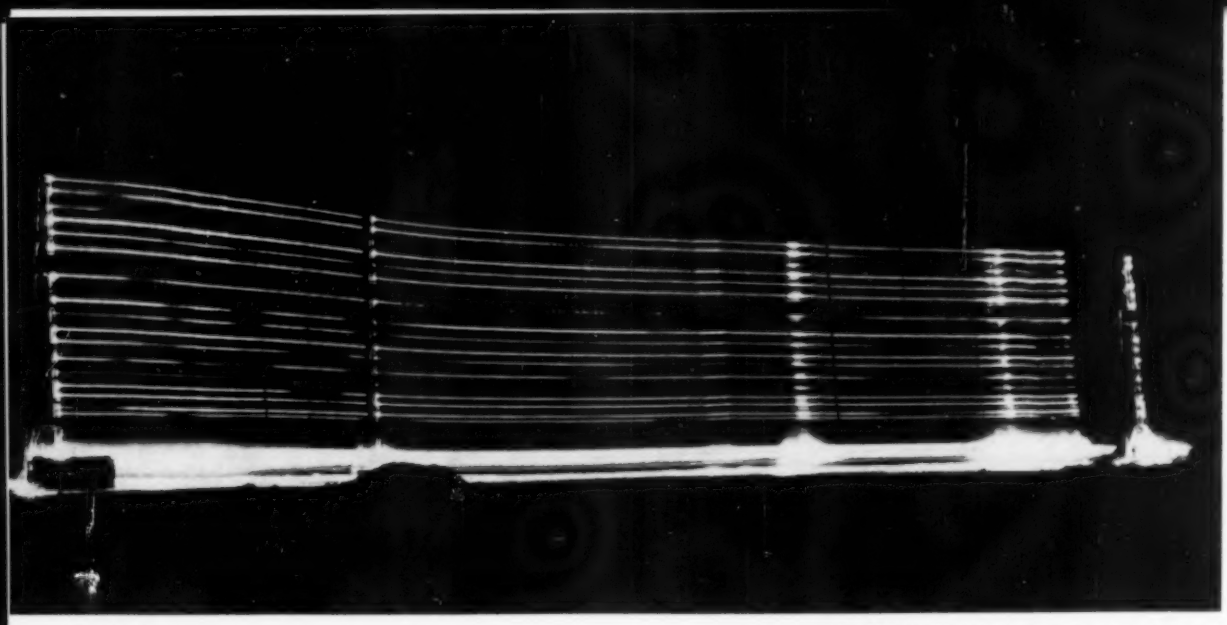


P 421.3

It's smooth skidding for Rig 4 along the Canadian River bottom between nearby locations. Pause at left center occurred when bulldozers stopped to move a sand dune

When there's "just not enough hours in a day" — try a

RIG SKID BY NIGHT

MOVEMENT of oilfield equipment at night isn't as prevalent as it used to be — but certainly more dramatic.

Huber Corporation's oil and gas division skidded one of its rigs in the Borger, Texas, area at night, solving an old-age problem: How to add more working time to the day.

Photographers documented one particular rig movement in the Canadian River bed through this time exposure.

Rig 4 crews had just completed drilling Huber's State "A" No. 36 well and were moving to a nearby location. The operation was under the direction of Al Summers, superintendent of the South Plains District, and Vaden Fowler, assistant general drilling and production superintendent.

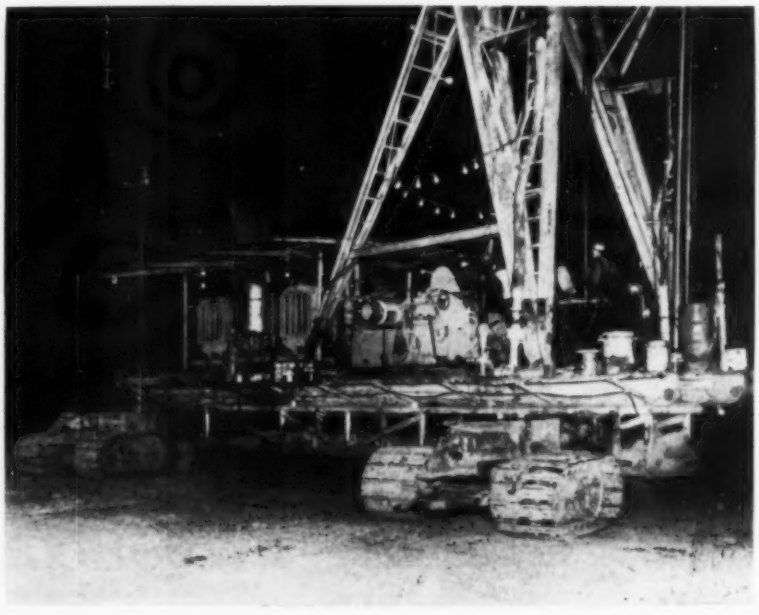
To get Rig 4 on the move, crews placed two skids, or girders, under the rig floor. These were supported with treaded dollies. The dollies were hitched to three (sometimes four or more) bulldozers for the movement. Other bulldozers cleared the right of way as the operation progressed. The rig was resting on its new location long before dawn.

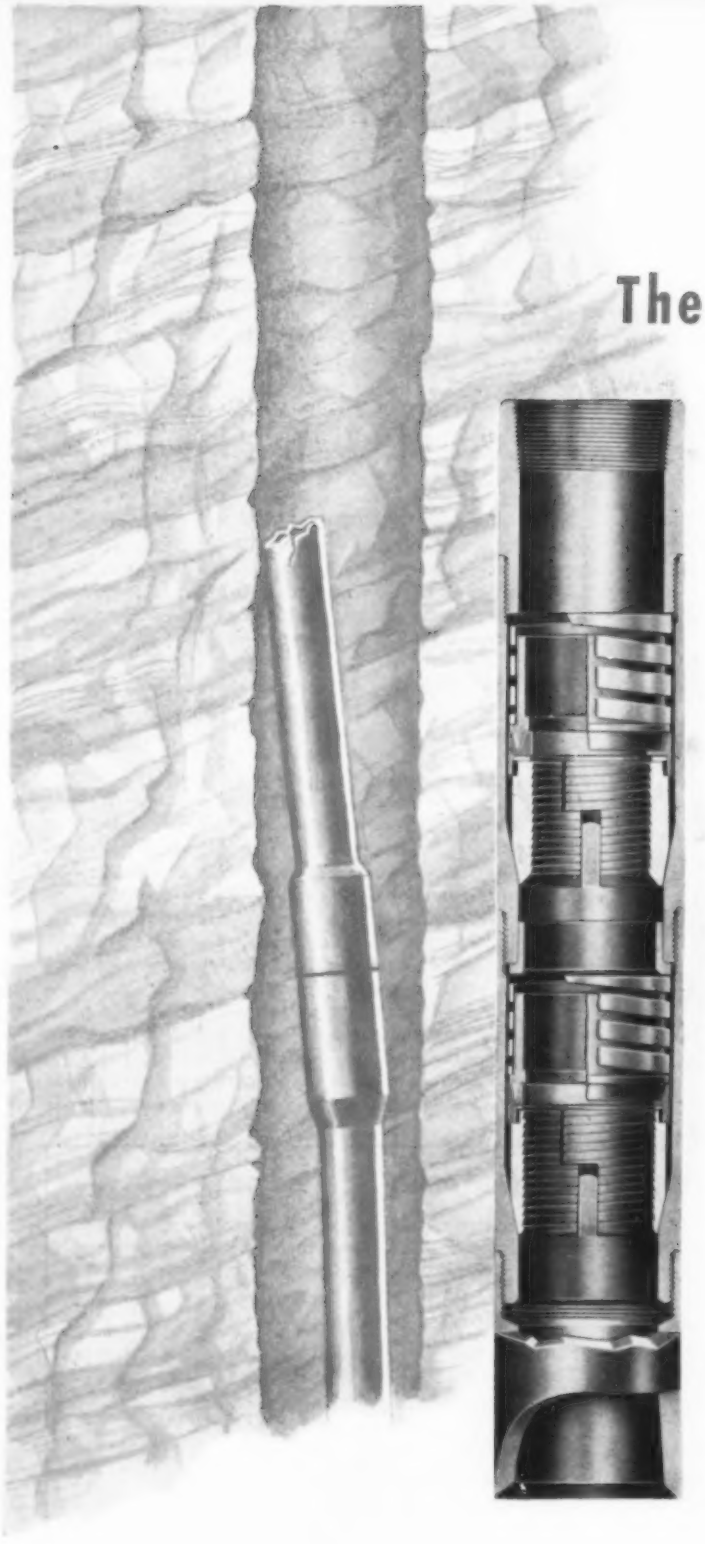
Acknowledgment

Credit for these excellent photographs goes to Huber News, publication of J. M. Huber Corporation, Borger, Texas.

* * *

Rig 4 gathers "most of its eggs onto one basket" before being moved upright. New location has been prepared in advance to eliminate delay at further work.





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CASING PROGRAM

Harold Blum

PROPER selection and handling of oil well casing is one of the most important phases of drilling operations. Casing costs usually represent a large percentage of the total drilling and completion expenses. In exploratory wells, decision to set casing for conclusive testing of possible producing zones is often the most important one made. Protection from caving formations, support of surface equipment and, in conjunction with cement, the prevention of unwanted fluid production are the main functions of casing.

A casing program is a systematic plan for proper selection and handling of casing. It is the purpose of this chapter to discuss the factors which must be considered in order to have an effective program.

Casing Characteristics

Before describing methods of selection and handling casing, it is necessary to understand casing properties. There are many possible ways to describe and classify casing. In this section, the following breakdown will be used: (1) casing functions; (2) seamless steel casing; (3) other types of casing.

Casing Functions. Conductor, surface, intermediate, and oil production strings are the four classifications of casing according to function. Conductor pipe is used primarily where the surface soil is weak. It makes the cellar more stable and provides a good start for subsequent drilling. Where surface is stable, this type of casing is not required. Fig. 1 illustrates a hole containing surface, intermediate and oil strings.

Surface pipe or casing is used with cement to protect fresh water sands from contamination and to support surface equipment such as blow-out preventers. How deep a hole is set for surface casing depends primarily on the depth of the fresh water sands and the expected stresses due to high pressure formations. The minimum legal length of surface casing to be set in a given area is fixed by the various state agencies.

Cement slurry is pumped through the casing and up the annulus until the slurry reaches the surface. Occasionally slurry is dumped in the annulus if it is not filled up to the top.

Intermediate, protective, or water strings are set when cave-ins, wash-outs, or other problems in upper formations make drilling difficult and when smaller drill pipe and bits are necessary for deeper drilling due to rig limitations. With present improved methods of drilling and mud control, the need for the intermediate string has lessened to the point where it is seldom employed even in wells as deep as 10,000 ft.

Production strings are set either above the producing formation for open-hole completions or through the zone when production will be through perforations.

In most cases all strings extend to the surface. The production string in some cases, however, extends only to the bottom of an intermediate string. In this case, the string is known as a liner. Liners are sealed to the protector string. While use of liners can cut cost of casing, many problems such as junction leaks and less satisfactory cementing jobs (than on full length strings) limit their desirability.

Seamless Steel Casing. The most widely used type of casing is seamless steel. This pipe is manufactured from solid round bars by piercing the centers at high temperature until the desired wall thicknesses are obtained.

Seamless steel casing joints come furnished with a screwed coupling and thread protectors. Fig. 2 illustrates the difference between long and short couplings.

Table 1 describes in detail the properties and dimensions of seamless, API, non-upset* casing. There are other types

*Associate Professor, Texas Technological College, Lubbock, Texas.

CASING PROGRAM CHECKLIST

A printed form can be developed which lists most of the pertinent factors that go into a good casing program. The completion of this form by responsible personnel forces detailed consideration of each casing job. Proper planning and follow-up will meet the casing program objectives of setting casing safely at minimum cost.

A — PLANNING

- ☐ Well name and location
- ☐ Total depth
- ☐ Time schedule of operations
- ☐ Number and depth of strings
- ☐ Casing availability (source, person to contact, sizes and types)
- ☐ Cost of available pipe
- ☐ Transportation (who will do it, cost, how much prior notice)
- ☐ Specifications of casing (results of design based on available pipe, alternatives)
- ☐ Personnel (responsible for inspection, make up, running, setting, and records)
- ☐ Records (casing tally, cementing data, landing information, remarks)
- ☐ Cementing plan
- ☐ Landing plan
- ☐ Casing accessories
- ☐ Special instruction

B — OPERATION

- ☐ Order (specification, cost, date)
- ☐ Receiving (inspection, storing)
- ☐ Assembly and running (casing tally and remarks)
- ☐ Cementing (this is a separate study)
- ☐ Landing

C — FOLLOW-UP

- ☐ Remarks about deviations from plan and any subsequent casing problems.

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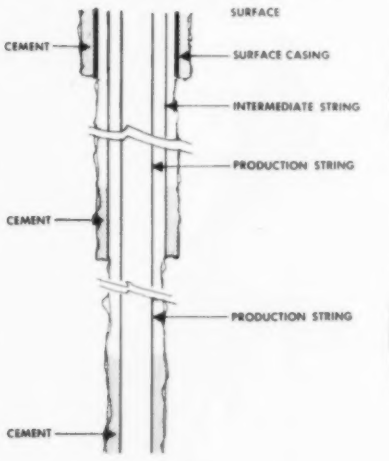
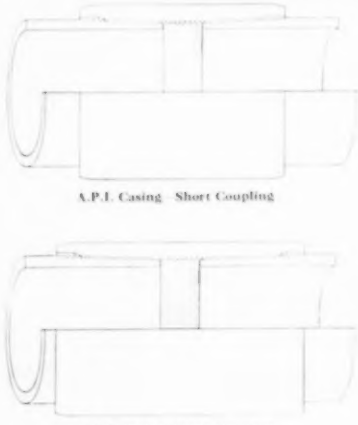


FIG. 1. Casing strings in well.



— Courtesy National Tube.

FIG. 2. Seamless API casing.

of seamless casing which vary from those described in the above table. Information on these types can be obtained from the various manufacturers' literature.

The complete description of API casing includes outside diameter, nominal weight per foot (based on weight of 20 ft of casing including coupling), steel grade, and type of coupling [long thread and coupling (LT&C) or short thread and coupling (ST&C)]. For example, 5½-in. OD, 15.5 lb per ft, J, ST&C is a complete description of a section of casing. Once this description is known, it is possible from Table 1 to obtain the inside diameter, wall thickness, drift diameter (maximum size tool which can be run through the casing), outside diameter of coupling which in turn is basic information necessary to determine bit size (this

TABLE 1. Seamless API Casing (Non Upset)

Dimensions and Properties

Size: OD	Weight per foot: Nominal: threads and coupling	Weight per foot: Plain end	Dimensions: Wall thickness	Dimensions: Inside diameter	Dimensions: Drift diameter	Dimensions: Coupling OD: API Non-upset, upset and buttress	Dimensions: Coupling Length: API Short	Dimensions: Coupling Length: API Long	Steel grade	Internal pressures: Mill test	Internal pressures: Yield (min.)	Internal pressures: Ultimate: Min.	Internal pressures: Ultimate: Average	Collapse: Setting depth, SF 1⅛	Collapse resistance (psi)	Tension based on minimum properties: Short coupling: Ultimate joint strength (min.)	Tension based on minimum properties: Long coupling: Ultimate joint strength (min.)
In.	Lb		In.							PSI				Ft	PSI	1000 Lb	
5½	13.00	12.84	.228	5.044	4.919	6.050	6¾	...	F	1600	1810	4140	4560	2950	1810	95	
	14.00	13.70	.244	5.012	4.887	6.050	6¾	...	H	2800	3110	5990	6650	4340	3110	139	
	14.00	13.70	.244	5.012	4.887	6.050	6¾	...	J	3000	4270	7980	8870	5640	4270	186	
	15.50	15.35	.275	4.950	4.825	6.050	6¾	8	J	3000	4810	9000	10000	6860	4810	211	247
	17.00	16.87	.304	4.892	4.767	6.050	6¾	8	J	3000	5320	9940	11050	8000	5320	234	275
	17.00	16.87	.304	4.892	4.767	6.050	6¾	8	N	3000	7740	10940	12160	10470	7740	273	320
	20.00	19.81	.361	4.778	4.653	6.050	6¾	8	N	3000	9190	13000	14440	13480	9190	326	482
	23.00	22.54	.415	4.670	4.545	6.050	6¾	8	N	3000	10560	14940	16600	15820	10560	375	440
7	17.00	16.70	.231	6.538	6.413	7.656	7¼	...	F	1300	1440	3300	3630	1960	1100	118	
	17.00	16.70	.231	6.538	6.413	7.656	7¼	...	H	2100	2310	4460	4950	2440	1370	160	
	20.00	19.54	.272	6.456	6.331	7.656	7¼	...	H	2500	2720	5250	5830	3410	1920	191	
	20.00	19.54	.272	6.456	6.331	7.656	7¼	...	J	3000	3740	6990	7770	4440	2500	254	
	23.00	22.63	.317	6.366	6.241	7.656	7¼	9	J	3000	4360	8150	9060	5850	3290	300	344
	23.00	22.63	.317	6.366	6.241	7.656	7¼	9	N	3000	6340	8960	9960	7640	4300	350	400
	26.00	25.66	.362	6.276	6.151	7.656	7¼	9	J	3000	4980	9310	10340	7220	4060	345	395
	26.00	25.66	.362	6.276	6.151	7.656	7¼	9	N	3000	7240	10240	11380	9460	5320	402	460
	29.00	28.72	.408	6.184	6.059	7.656	7¼	9	N	3000	8160	11540	12820	11320	6370	454	520
	32.00	31.68	.453	6.094	5.969	7.656	7¼	9	N	3000	9060	12820	14240	13160	7400	505	578
	35.00	34.58	.498	6.004	5.879	7.656	7¼	9	N	3000	9960	14080	15650	14970	8420	554	635
	38.00	37.26	.540	5.920	5.795	7.656	7¼	9	N	3000	10800	15270	16970	16140	9080	600	688
8⅝	24.00	23.57	.264	8.097	7.972	9.625	7¾	...	F	1200	1340	3060	3370	1690	1340	161	
	24.00	23.57	.264	8.097	7.972	9.625	7¾	...	J	2700	2950	5510	6120	2540	1430	288	
	28.00	27.02	.304	8.017	7.892	9.625	7¾	...	H	2300	2470	4760	5290	2810	2470	252	
	32.00	31.10	.352	7.921	7.796	9.625	7¾	...	H	2600	2860	5510	6120	3750	2860	295	
	32.00	31.10	.352	7.921	7.796	9.625	7¾	10	J	3000	3930	7340	8160	4870	3930	393	437
	36.00	35.14	.400	7.825	7.700	9.625	7¾	10	J	3000	4460	8340	9270	6080	4460	448	499
	36.00	35.14	.400	7.825	7.700	9.625	7¾	10	N	3000	6490	9180	10200	7950	6490	522	581
	40.00	39.29	.450	7.725	7.600	9.625	7¾	10	N	3000	7300	10330	11480	9580	7300	589	655
	44.00	43.39	.500	7.625	7.500	9.625	7¾	10	N	3000	8120	11480	12750	11240	8120	654	729
	49.00	48.00	.557	7.511	7.386	9.625	7¾	10	N	3000	9040	12790	14210	13100	9040	729	812
9⅝	29.30	28.04	.281	9.063	8.907	10.625	7¾	...	F	1200	1280	2920	3210	1530	860	185	...
	32.30	31.03	.312	9.001	8.845	10.625	7¾	...	H	2100	2100	4370	4860	2350	1320	279	...
13⅜	48.00	45.98	.330	12.715	12.559	14.375	8	...	F	750	1080	2470	2710	1000	560	260	...
	48.00	45.98	.330	12.715	12.559	14.375	8	...	H	1200	1730	3330	3700	1320	740	352	...
	54.50	52.74	.380	12.615	12.459	14.375	8	...	J	1900	2730	5110	5680	2030	1190	545	...
16	55.00	52.36	.3125	15.375	15.188	17.000	9	...	F	600	850	1950	2150	500	280	258	...
	65.00	62.58	.3750	15.250	15.062	17.000	9	...	H	1100	1640	3170	3520	1140	640	423	...
	75.00	72.72	.4375	15.125	14.938	17.000	9	...	J	1800	2630	4920	5470	1800	1010	662	...
	84.00	81.97	.4950	15.010	14.822	17.000	9	...	J	2000	2980	5570	6190	2630	1480	753	...

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will be covered in detail later) plus information about the strength characteristics of the casing. From the description given above (5½-15.5-J-ST&C) the following has been obtained from Table 1:

ID (inside diameter)	4.950 in.
Wall thickness	0.275 in.
Drift diameter	4.825 in.
OD coupling	6.050 in.
Collapse resistance	4,810 psi
Ultimate joint strength	211,000 lb

*Upset casing has a thicker wall under the threads. The resulting casing is stronger but has a smaller working inside diameter.

Grades of steel differ in their carbon content. Strengths of the various grades and other useful data are presented in Table 2. A new grade (P-110, Ultimate Strength 110,000 psi) has been placed on the market and is being used in deep wells.

Other Types of Casing. Casing can be described as follows: 1. By function, 2. Method of manufacture, 3. Type of coupling or joint, 4. Material type.

For example, types include seamless, welded, and riveted casing. Casing is usually threaded but may also be equipped with welded joints. Some special threads other than the standard API are manufactured and used to improve tensile strength.

For shallow wells, less expensive casing types such as spiral welded, corrugated, and riveted sheet steel are available.

Alloy steels are used where corrosion is a problem. Plastic pipe, which is easy to handle and resists corrosion, is available.

Casing Costs

Study of casing expenses is an integral part of the casing program. Cost of casing, transportation, rig time for handling and running casing, and supervision are direct casing expenses. Cost of casing cement jobs could also be considered as part of the casing expenditure.

Table 3 lists approximate costs as of December, 1956, for various sizes, grades, weights, and couplings. Shipping charges from the FOB point to the location must be added to the casing cost.

Part of the expense can sometimes be recovered when a well is abandoned. This is true because it is possible to cut casing loose above the cement and bring it to the surface. If the casing is in good condition it can frequently be reused. Otherwise it has some scrap value.

Second-hand casing has been used more often in recent years due to occasional shortages. For non-critical applications even when there are no shortages, this casing has been used to take advantage of the lower cost.

Casing Design

The term casing design simply means correct selection of casing. Correct, in this case, signifies (1) that the casing will not fail at any time during the life of a well, (2) that the casing size will be adequate for efficient production, and (3) that the cost to satisfy the first two conditions will be a minimum.

Factors involved with proper selection of casing size are discussed in a later section of this chapter. Once the size is set, selection of casing to prevent failure at minimum cost becomes the prime problem.

A survey made by the Mid-Continent District Study Committee on Casing Programs (API)[2] indicated that failures attributed to design practices are almost nonexistent. This means that the accepted practice method for selection of casing is satisfying the previously mentioned condition that casing must not fail. On the other hand there remains the question of minimum cost.

TABLE 2. Range Length of API Casing
All Lengths in Feet

	Range 1	Range 2	Range 3
Total range length (incl.)	16-25	25-34	34 or more
Range length for 95% or more of carload			
Permissible variation (max.)	6	5	6
Minimum permissible length	18	28	36
Range length for 5% or less of carload			
Permissible variation (max.)	9	9	...
Minimum permissible length	16	25	34
*Jointers: Minimum length of shortest piece	5	5	5

Tolerance on API Standard Casing

Item	Tolerance
Pipe weight	
For any length of pipe	Calculated weight +6½% −3½%
Carload weight	Calculated weight −1¾%

Physical Properties of API Casing
Minimum Tensile Test Properties

Physical properties (min.)	API Grade symbol F-25	H-40	J-55	N-80
Ultimate strength, psi	40,000	60,000	75,000	100,000
Yield strength, psi	25,000	40,000	55,000	80,000
Elongation in 8 inches, %	20			
Elongation in 2 inches, %	30	27	20	16

It is probable that in many cases overdesign or in other words overexpenditure is the result of using the accepted safe method for casing selection. This possibility was recognized by the API committee previously mentioned. Saye and Richardson[3] reported that substantial savings were accomplished in the Elk City field, Oklahoma, by using lower than conventional safety factors. Bowers[4] suggested that the basic assumptions in the accepted design method were unrealistic, Texter,[5] on the other hand, indicated (in discussion of effect of tension on collapse resistance) that there are still too many factors unknown to justify radical changes in the design method.

The trend in design of casing is certainly in the direction of using less steel either by using the conventional method with lower safety factors or by considering the physical conditions which actually exist in a given case as Bowers[4] did.

Casing Design — Causes of Failure

In order to design casing strings that will not fail, the causes of failure must be known. Texter[5] presented a thorough study of all known reasons for casing troubles.

The principal factors considered in casing design are: (1) collapse, (2) tension, and (3) bursting (internal pressure).

1. Collapse failure is the result of unbalanced external pressures. When it occurs, the casing will flatten. Collapse can occur when the fluid pressure outside of the casing is very large compared to the internal pressure. This might happen when the casing is empty and the full pressure due to the head of mud or formation water outside the pipe is exerted (neglecting counteracting buoyancy effects).

If the casing were empty at 8000 ft and a 11.6 lb per gal mud were used (0.602 psi per ft from Table 6), the relative external pressure which the casing must withstand is 8000 ft $\times$ 0.602 $\frac{\text{psi}}{\text{ft}}$ = 4816 psi. Swabbing operations can also produce collapse stresses. Failure may also occur during a squeeze job if the high pressure exerted through the perforations affects the casing above the packer. Fig. 3 shows how collapse might occur during such an operation.

Besides fluid pressure failures, collapse can be caused by mechanical forces. For example, shifting formations or earthquakes can cause trouble. Dents that might result from bad handling can greatly reduce collapse resistance. It has been pointed out[5] that deformation of 1 percent can reduce collapse resistance by 25 percent. For this reason, casing must be handled carefully. Tension will also reduce the col-

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lapse resistance. This factor is considered quantitatively in casing design.

2. Tension in casing results from (1) its own weight, (2) pulling through tight sections during reciprocation, (3) temperature changes during and after cementing.

The tension caused by its own weight is partially offset by the buoyancy in mud. For example, the weight of 12.0 lb per gal mud displaced by 1000 ft of 7 in. 23 lb per ft casing when mud is both in and outside the pipe is 4209 lb. This weight according to Archimedes Principle is subtracted from the weight in air to determine the effective weight in mud of the casing. In this case, it is 18,791 lb.

10,000 ft of 18 lb per ft 5½-in. casing weighs 180,000 lb in air but only 141,480 lb in a 14.0 lb per gal mud. Buoyancy correction factors are available in various handbooks.

When casing is run into a hole partially empty, the buoyancy effect is very large and the casing is "floated" in. In the conventional design method, buoyancy is not considered. This is one of the principal criticisms aimed at it.

When casing is cemented, the heat of hydration causes significant temporary temperature increases which cause expansion and increase compressive stresses. When the subsequent cooling occurs, if the casing is fixed on both top and bottom, shrinking will tend to occur and tension stresses will be severe. This in turn would affect collapse resistance as pointed out before.

3. Bursting failure which produces longitudinal breaks in casing occurs as a result of high relative internal pressures. These pressures are equal to the expected bottom hole pressure less the pressure due to the weight of the fluid. After the casing is set, a pressure test with mud in the casing at the expected pressure checks it for leaks and bursting strength. The internal pressure would be most severe at the top of the casing when gas is present inside. Some designers assume the full formation pressure (about 0.5 psi per ft) for this case while others subtract the weight of the gas. For example, if the pressure in a 6000 ft gas formation is 3000 psi, the pressure at the surface would be about 2500 psi. The actual figure depends on the average density of the gas.

Some other causes of casing trouble are:

1. **Thread failures due to shocks,**
2. **Leakage,**
3. **Wear from contact with drill pipe, wire line, tubing and rods,**
4. **Torsion — if casing is rotated during cementing operations,**
5. **Improper handling,**
6. **Corrosion — external and internal.**

Whereas the only factors which will be considered in the design method in this chapter are collapse, tension and bursting, an effective program must consider the less prominent causes of failure. For example, if external corrosion is a problem, plans should be made to either prevent it by cementing off key formations or using inhibitors, live with it by using thicker casing, or consider cathodic protection.

Wear is another factor that receives attention of some designers.

Casing Diameter Selection

The first consideration in the selection of casing is the size (OD) of the production string. No simple rules can be laid out for reaching this first decision, however the important factors are listed and discussed below.

1. Drilling cost. As the hole diameter increases so will the cost of drilling and completion. This cost of large diameter holes should be balanced against expected economic advantages.

2. Methods of production. A well may flow naturally in its early history but may require pumping later. The hole should be large enough so that necessary equipment will fit in it.

3. Production rates. This is an important factor only when production rates are high enough to cause appreciable pressure drops in the production tubing.

4. Possibilities of multi-zone completion. Hole sizes should be large enough to handle equipment for multi-zone completion if this is a reasonable possibility.

5. Number of intermediate strings. If the expected drilling conditions necessitate one or more intermediate strings, the maximum size of the production string will be limited. This problem will be discussed in more detail at the end of this section.

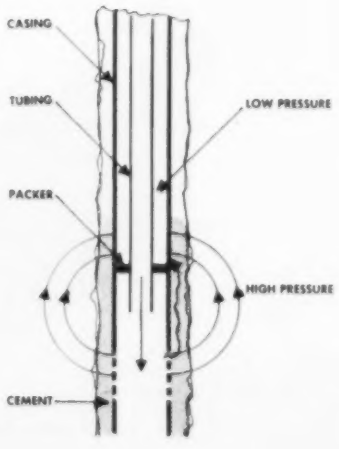
6. Nature of fluids produced. This factor is important primarily because it affects the choice of production equipment. In turn, the downhole equipment and accessories limit the minimum hole size.

7. Rig limitations. Normally, the selection of a rig depends on the size and depth of the hole to be drilled. There are cases, however, when rig selection is limited in a given area. In these cases, the size of the hole and casing is determined by the rig capabilities.

8. Workovers. If experience indicates that remedial work is common, the hole size should be large enough to accommodate necessary equipment.

TABLE 3. Approximate Cost of Seamless Steel API Casing (as of December, 1956) FOB — Barge — Houston

Casing O D	Weight (lb/ft)	Grade	Coupling L-LT&C S-ST&C	Price (Dollars per 100')
5½"	14	H	S	147
	14	J	S	151
	15.5	J	S	164
	15.5	J	L	172
	17.0	J	S	177
	17.0	J	L	186
	17.0	N	L	218
	20.0	N	L	257
	23.0	N	L	295
7"	35.0	N	L	429
7⅝"	38.0	N	L	435
	26.4	J	S	273
	26.4	J	L	286
8⅝"	32	H	S	316
	32	J	S	324
10¾"	40.50	H	S	399
	40.50	J	S	409
13⅜"	48	H	S	526
F O B Mill, Pennsylvania				
16"	65	H	S	681
20"	94	H	S	1045



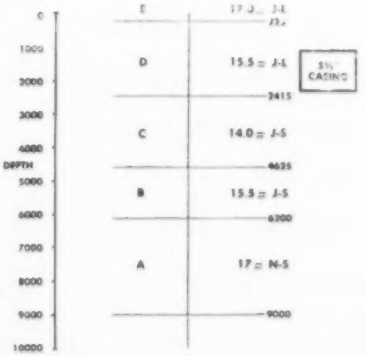


FIG. 3. (Left) How collapse failure might occur during a squeeze job.
FIG. 4. Combination string plan.

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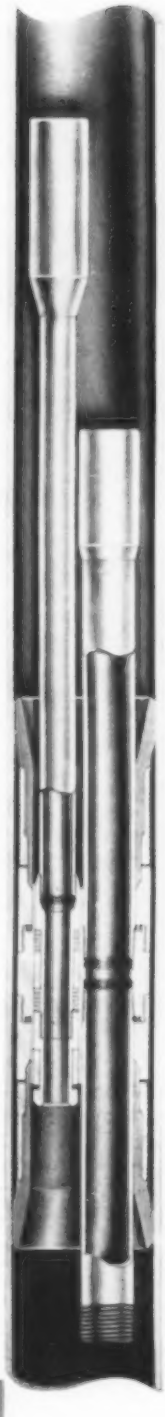

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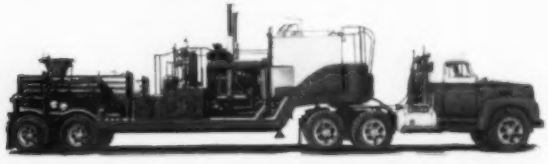

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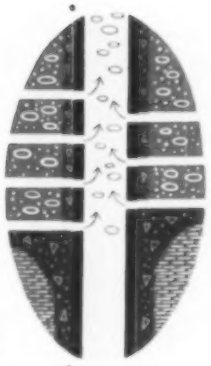

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TABLE 4. Clearance Guide for Casing Strings.

O D Coupling (inches)	Clearance (inches to be added to coupling O D
5	1.0
6	1.25
7	1.75
8	2.0
9	2.5
10	3.0
11	3.25
12	3.25
13 and up	3.50

TABLE 5. Common Bit Sizes. (Inches)

Common Bit Sizes (inches)		
3⅞	7⅞	10⅝
4½	7⅝	11
4¾	7¾	12
4⅝	7⅞	12¼
5⅛	8½	13¾
5⅝	8⅝	15
6	8¾	17½
6⅛	9	22
6¼	9⅝	23
6¾	9⅞	

TABLE 6. Density as a Function of Pressure Head

Density lb/gal	Pressure psi/ft	Mud Weight lb/gal	Pressure psi/ft
7.0	0.363	11.0	0.571
7.5	0.389	11.2	0.581
8.0	0.415	11.4	0.592
8.34	0.433	11.6	0.602
8.4	0.436	11.8	0.612
8.6	0.446	12.0	0.623
8.8	0.457	12.2	0.633
9.0	0.467	12.4	0.644
9.2	0.477	12.6	0.654
9.4	0.488	12.8	0.664
9.6	0.498	13.0	0.675
9.8	0.509	13.5	0.701
10.0	0.519	14.0	0.727
10.2	0.529	14.5	0.753
10.4	0.540	15.0	0.778
10.6	0.550	16.0	0.830
10.8	0.560		

9. Availability of casing. There have been many times in recent years where casing has been in short supply. Such a shortage can and has been the determining factor in establishing production string size.

10. Common practice. While all factors mentioned above should be considered independently, the experience of others in a given area should also be carefully studied before reaching a decision.

11. Exploratory vs development well. In an exploratory well, the prime purpose of drilling is to prove up the existence of commercial zones. Frequently, uncertainty requires the setting of casing. In the interest of economy, slim-hole drilling and completion may extend the exploration budget. This should be weighed against possible production problems at some later date.

When the diameter of the casing has been fixed for the production string, the selection of bit and upper casing string sizes can be determined. The method for selecting the above mentioned sizes can best be illustrated by an example.

EXAMPLE 1. What bits and casing will be used in a 10,000-ft well if the production string will consist of 5½-in. casing? An intermediate string will bottom at 5500 ft, and surface pipe will be run to 1500 ft.

1. What size bit will allow 5½-in. casing to be run?

Referring to Table 1 (5½-in. OD) it can be seen that outside diameter of the coupling is 6.050 in. This means that the bit size necessary to permit the casing to be run must exceed 6.050 in. A clearance beyond this diameter must be provided to account for mudcake, casing appliances such as centralizers and scratchers, and unusual hole conditions (e.g. caving formations, crooked hole). While there are no rules available which apply to every case, Hill[1] gave a guide which correlated clearance with maximum joint size and casing length. Table 4 is a guide to clearance selection which takes into consideration joint size and maximum probable setting depths. Using Table 4 for the stated problem, a clearance of 1.25 in. is suggested for the 6.050-in. coupling (exact interpolation of data is not warranted since the table is only a guide). This means the bit size required should be at least 6.050 + 1.25 = 7.30 in.

Referring to Table 5 which lists common bit sizes, the 7⅞-bit would be selected.

2. Through what minimum size intermediate casing string will the 7⅞-in. bit pass?

The 7⅞-in. bit selected for the production string must fit through the intermediate casing string. The drift diameter column in Table 1 indicates the maximum size tool which will go through any size casing. An examination of this column shows that the 7⅞-in. bit will pass through any 8⅝-in. casing since the drift diameter varies from 7.386 in. to 7.972 in.

3. What size bit will allow 8⅝-in. casing to be run?

From Table 1 the coupling OD is 9.625 in. Table 4 indicates that the clearance should be 3 in. or the minimum bit size 9.625 in. + 3 in. = 12.625 in. Table 5 shows the next larger bit size to be 13¾ in.

4. What size surface casing should be used to permit a 13¾-in. bit to pass through it?

Table 1 shows that the smallest casing that will meet the above requirements is 16 in. (drift diameter ranges from 14.822 in. to 15.188 in.).

5. The last step in this problem is to determine the bit size that will allow the surface casing to be run.

			Reference
Coupling OD	17.000	in.	Table 1
Clearance	3.5	in.	Table 4
Minimum bit size	20.5	in.	
Actual bit size	22	in.	Table 5

Summary:

	Production	*Intermediate*	*Surface*
Casing size (OD)	5½	8⅝	16
Coupling OD (inches)	6.050	9.625	17.000
Clearance (inches)	1.25	3	3.5
Minimum bit size	7.30	12.625	20.5
Actual bit size	7⅞	13¾	22

Casing Design — Surface Casing

Design of surface casing is frequently neglected on the assumption that cement in the annulus from the shoe to the surface provides all the strength necessary. On that basis, any kind of casing of the proper size will do. This assumption seems to be justified in many cases for shallow wells, especially if the cement job is properly handled. In many instances, however, cementing of surface casing is not as carefully planned as for the deeper strings.

In the API study[2] of casing string design factors, it was reported that many operators do consider collapse, tension and bursting when selecting surface casing. Wear and corrosion are also considered by some. One company used only J-55 grade pipe which almost eliminated the need for design.

EXAMPLE 2. 13⅜-in. surface casing is to be set to 1500 ft. Specify the casing to be ordered. Internal pressure is not expected to exceed 1000 psi. Assume conventional safety factors.

Conventional safety factors (SF) are 1.125 (1⅛) for collapse, 1.8 for tension, and 1.1 for internal (or burst). The conventional method assumes (1) that the pipe is empty or in other words exposed to the full pressure of the external column of mud, and (2) that buoyant forces of the mud on the casing are negligible. It is frequently assumed that the external column of fluid exerts a pressure of 0.5 psi per ft (9.625 lb per gal) (Table 6).

1. Collapse. At 1500 ft the column of liquid would exert $1500 \text{ ft} \times 0.5 \frac{\text{psi}}{\text{ft}} = 750$ psi. The casing should be able to withstand $\frac{(\text{SF})}{1.125} \times 750 = 844$ psi. Under Collapse Resistance column in Table 1 for 13⅜-in. casing, it can be seen that the first type of casing that can withstand 844 psi is the 54.50 lb per ft, J grade: It has a collapse resistance of 1140 psi.

The column headed Collapse Setting Depth, SF 1⅛, was prepared from the collapse resistance data for the safety factor and mud weight conditions of this problem. Using this column the selection of the proper casing for collapse is easier. In this case where 1500 ft is the setting depth 13⅜-in., 54.50 lb per ft, J grade is required. This casing could be set as deep as 2030 ft, according to the table.

Conclusion: 13⅜-in., 54.50 lb per ft, J grade steel will satisfy the collapse requirements.

2. Tension. The casing selected above comes with a short coupling that has an ultimate joint strength of 545,000 lb. (Table 1.) Using a safety factor of 1.8, the maximum weight to be placed on this casing is $\frac{545{,}000}{1.8} = 303{,}000$ lb. 1500 ft of 54.50 lb per ft casing weighs 81,750 lb.

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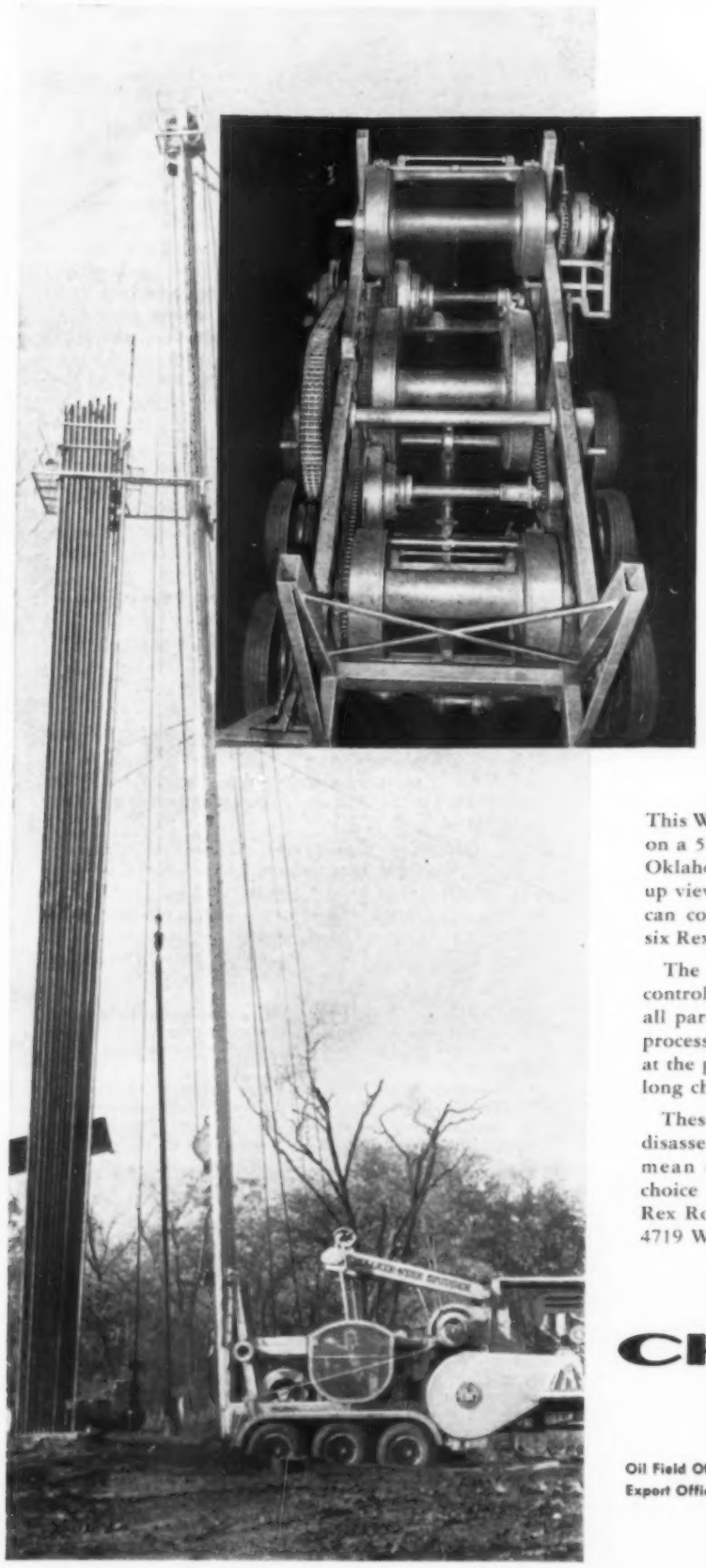

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Conclusion: 13⅜-in., 54.50 lb per ft, J, ST&C is satisfactory for tension.

3. Internal Pressure. The selected casing has a minimum yield pressure of 2730 psi (Table 1). Applying a safety factor of 1.1 means it can be safely used wherever the internal pressure does not exceed $\frac{2730}{1.1} = 2480$ psi. This is safer than required.

Conclusion: Specify for surface casing 1500 ft-13⅜-in., 54.5 lb per ft, J, ST&C.

The column showing the maximum setting depth is obtained from collapse resistance data in this way. For the above example 13⅜-54.5-J, ST&C has a collapse resistance of 1140 psi. The highest collapse stress to which it may be subjected therefore is $\frac{1140}{1.125} = 1013$ psi. For the 0.5 psi per ft mud this means that the maximum setting depth is $\frac{1013}{0.5} = 2026$ ft.

This is rounded off to the nearest 10 ft or 2030 ft which is listed in Table 1.

EXAMPLE 3. 9⅝-in. surface casing is to be set at 2500 ft. Experience indicates that safety factors of 1.0 for collapse and 1.5 for casing are workable. Mud weighs 9 lb per gal. Internal pressure is not expected to be significant. Specify the casing which will meet the requirements. The steps to the solution can be handled by the following form.

EXAMPLE 3. Surface Casing Selection.

1. Casing size — 9⅝ in.
2. Length — (ft), 2500 ft.
3. Mud weight — (lb/gal), 9.0 lb/gal
4. Mud pressure — (psi/ft), 0.468 psi/ft
5. Safety factors — (sf)
   Collapse — 1.0
   Tension — 1.5
   Internal — Not considered
6. Collapse stress (mud pressure × length) — (psi), 1170 psi
7. Minimum casing requirements (collapse) — (psi), 1170 psi (Collapse stress × sf)
8. Casing description satisfying collapse requirements — 9⅝ in., 32.30 lb/ft, H
9. Coupling type — (short or long) — Short.
10. Ultimate joint strength — (lb) — 279,000 lb
11. Maximum allowable tension — (lb) — 186,000 lb (Ultimate strength/sf)
12. Tension due to weight of casing — (lb) — 81,250 lb Casing length × weight per ft. (therefore OK)
13. Internal stress expected — (psi), not considered
14. Minimum yield strength for selected casing — (psi)
15. Maximum allowable internal pressure — (psi) (Minimum yield strength/sf)
16. Remarks — No unusual wear or corrosion conditions are expected.
17. Description of casing selected—2500 ft, 9⅝-in., 32.3 lb/ft, H, ST&C.

EXAMPLE 4. Second hand 10¾ in., 51.0 lb per ft, N, ST&C casing is available. Inspection shows that it has maintained its original thickness and the threads are in good condition. To be sure that it is used safely, the safety factor for collapse is to be 1.5 that for tension 2.0, and internal pressure 1.3. Internal pressure is not expected to exceed 2500 psi. Mud weight is 10.0 lb per gal. How deep can this casing be set?

In this problem the properties of the casing for collapse resistance (3750 psi), tension (680,000 lb) and yield strength (5860 psi) are available.

1. Check for allowable internal pressure

$$\frac{5860}{1.3} = 4510 \text{ psi}$$

Since this is greater than 2500 psi the casing can be used. If it were not, the casing would not meet requirements and further calculations would not be necessary.

2. Check for allowable length of casing which can be supported in tension.

$$\text{Allowable weight} = \frac{680{,}000}{2.0} = 340{,}000$$

$$\text{Allowable length} = \frac{340{,}000 \text{ lb}}{51.0 \ \frac{\text{lb}}{\text{ft}}} = 6670 \text{ ft.}$$

3. Check for maximum setting depth which is safe from collapse.

$$\text{Maximum allowable collapse pressure} = \frac{3750}{1.5} = 2500 \text{ psi}$$

Mud pressure — 0.519 psi per ft (Table 6)

$$\text{Maximum length} = \frac{2500 \text{ psi}}{0.519 \ \frac{\text{psi}}{\text{ft}}} = 4820 \text{ ft}$$

Maximum safe setting depth for second hand casing is 4820 ft.

Casing Design — Combination Strings

Many intermediate and most production strings (for wells deeper than 3500 ft) consist of two or more sections that differ from each other in grade, weight, and type of coupling. This is called a combination string. The advantage of this arrangement over single weight and grade strings is economy. Savings ranging from a couple percent to 20 percent are possible. In other words, safety factors for single section weight and grade casings are larger than necessary and result in overdesigned casing.

Basic assumptions of physical conditions that will be used for design in this chapter are conservative but they are widely used.[2] The design procedure used here is not the most rapid but it is believed that the principles of the method are more clearly illustrated by its use. Hills[6] in his review of casing string design principles recommends the more rapid graphical method developed by Main.[7] Another time saver for design was developed by Kastor[8] who devised a procedure for eliminating the trial and error portion of the method to be used here.

Both the Kastor and the Main procedures should be studied when the fundamental ideas on casing design are understood, especially if string design is more than an occasional task.

The assumptions used in this method are:

1. Casing is empty, therefore the full head of the external liquid (mud or water) will be figured as the collapse stress.

2. The only tension stress considered will be that due to the weight of the casing in air. No consideration of buoyancy will be made.

3. Standard design conditions will mean a 1.125 safety factor for collapse, 1.8 for tension, 1.1 for internal pressure and an external fluid head pressure of 0.5 psi per ft.

Another limitation imposed only in this chapter is that no other casing will be considered other than that listed in Table 1. In practice other available types would be investigated.

EXAMPLE 5. Design a 9000 ft single weight and grade 5½-in. casing string. Use conventional safety factors and 0.5 psi per ft external pressure. Assume internal pressure will not exceed 1000 psi.

1. Collapse. From Table 1, collapse setting depth column — 17 lb per ft N will satisfy the worst expected collapse conditions.

2. Tension. 17-N-short coupling has an ultimate joint strength of 273,000 lb. With a 1.8 safety factor the maximum load which can be placed on it is $\frac{273{,}000}{1.8} = 152{,}000$ lb. How many feet of 17 lb per ft casing will 152,000 lb support?

$$\frac{152{,}000 \text{ lb}}{17 \ \frac{\text{lb}}{\text{ft}}} = 8940 \text{ ft}$$

In other words, the entire 9000 ft cannot be supported with the short coupling with the 1.8 safety factor. The designer at this stage has a number of choices.

a. He can reason that using the short coupling for the entire 9000 ft is not trifling appreciably with the safety factor especially in view of the fact that buoyancy which would lessen the load has been neglected. The weight of 9000 ft of 17 lb per ft casing is 153 000 lb. Safety factor using the short coupling is $\frac{273{,}000}{153{,}000} = 1.78$.

b. He can specify that the top 60 ft must have long coupling joints.

c. He can specify that the entire string have long couplings. The long coupling joint can support 10,460 ft of its own weight (calculated in same way as for the short coupling). A string of 9000 ft of 5½ 17 N — with long coupling would cost about $810

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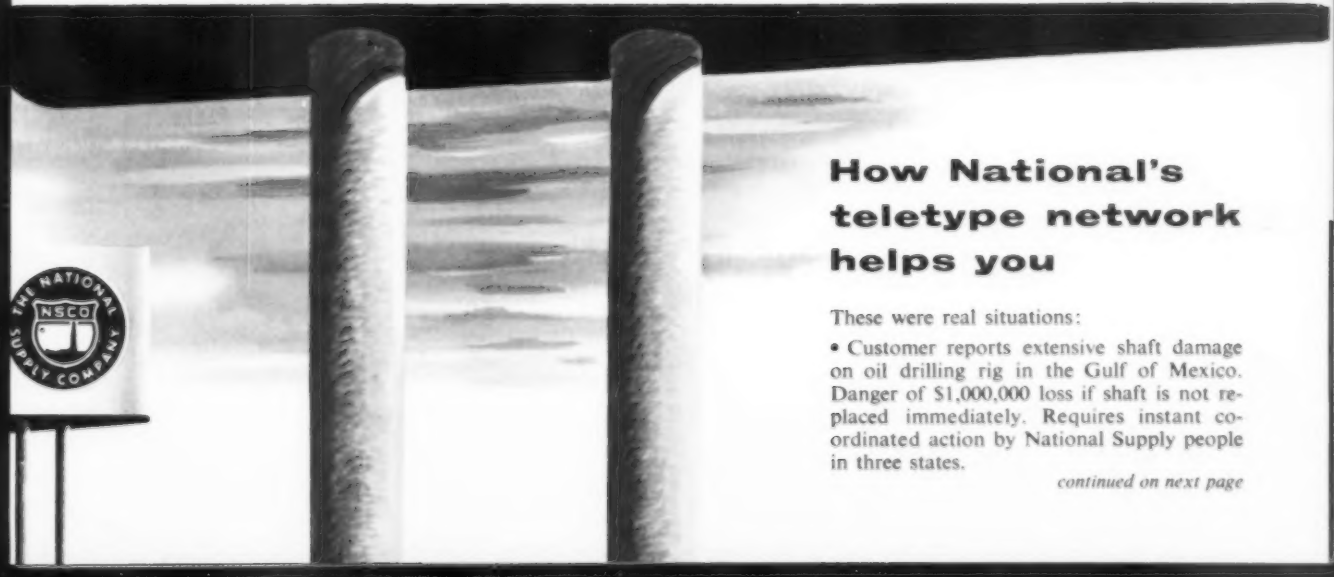

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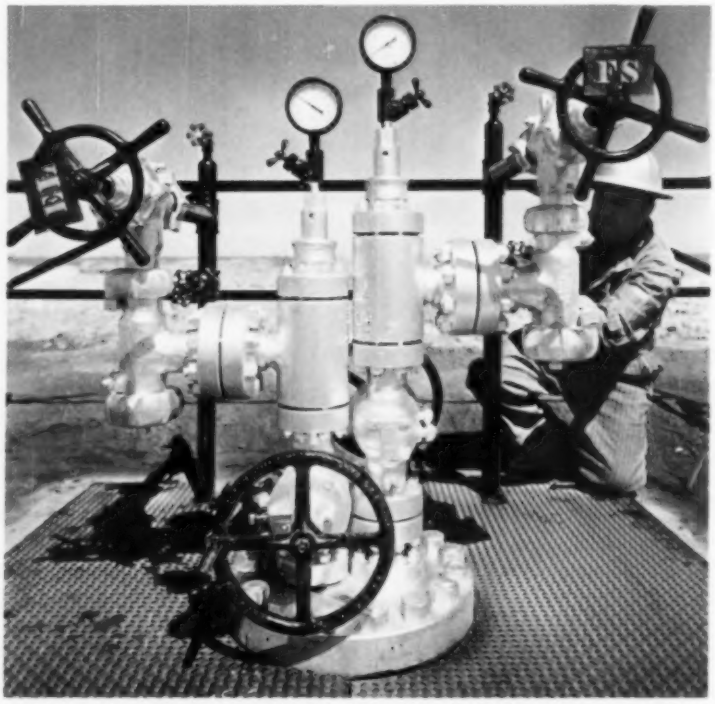

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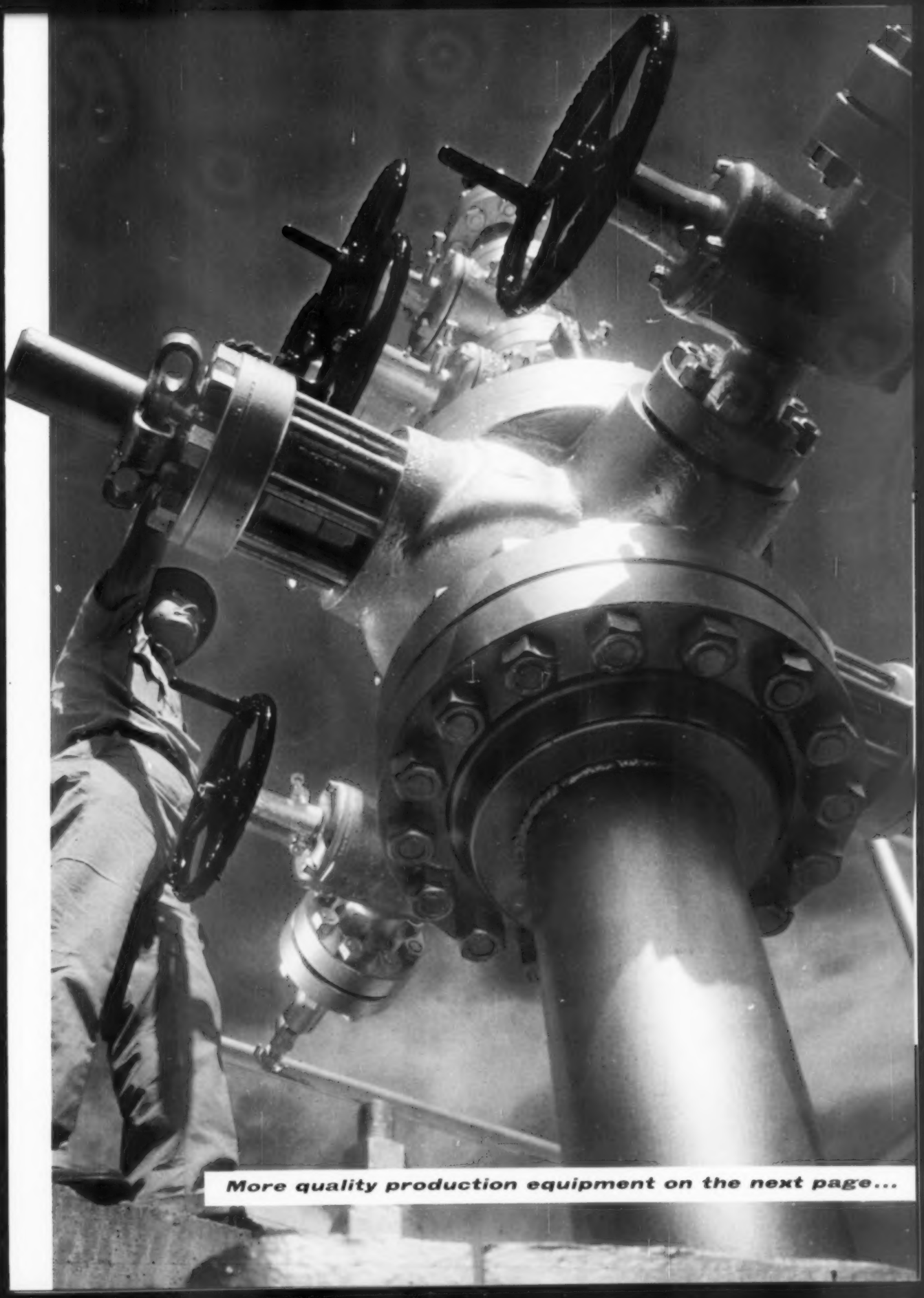

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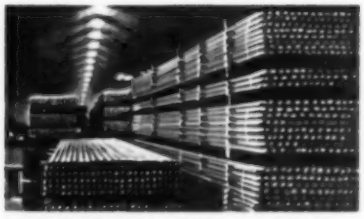

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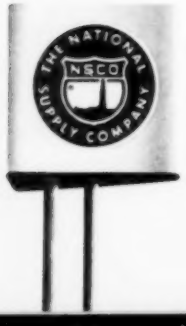

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more than one with the short coupling. (This assumes a difference of about $9 per 100 ft.) The first of the three choices seems to be the most reasonable.

3. Internal pressure. The minimum yield pressure is 7740 psi. The maximum allowable is 7740/1.1 = 7040 psi which is far greater than the expected 1000 psi maximum.

In the combination string, the lowest point is subjected to the greatest collapse stress. On this basis, as illustrated in Example 5, the bottom section is selected. At some point above the bottom, a lighter weight casing would be adequate to protect the string against collapse. It is the purpose of the calculations to be described in Example 6 to locate this changeover point. At some point above the first changeover, an even lighter casing would be adequate for collapse protection. The same types of calculations are used to determine this also. At each changeover point the final check on the adequacy of a section is to determine whether the joint strength is large enough to support all the casing below it. Whereas near the bottom of the string, tension stress is not great, at the top it controls the casing to be selected and collapse is negligible. Example 6 will be a combination string design with standard design conditions. Example 7 will be general.

EXAMPLE 6. Design a 9000 ft — 5½ in. combination casing string (assuming standard design conditions) for minimum weight. Assume internal pressure can be neglected.

Section A. — 9000 ft to ?

1. Setting depth column in Table 1 shows that 17-lb N can be set safely at 10,470 ft whereas 17-lb J can only be set to 8000 ft. Therefore, specify for Section A — 5½ in. 17 lb per ft N casing. Make a sketch similar to Fig. 4 and fill in as data becomes available.

2. The next lighter casing listed in Table 1 for 5½-in. casing is 15.50 lb per ft. It could be set at 6860 ft (Table 1) if there were no tensile load. Since the weight of the 17.0 lb per ft pipe places a tensile stress on the 15.5-lb casing, its collapse resistance is lowered. This means that its safe setting depth is above 6860 ft. Fig. 5 and 6 show how this type of loading decreases collapse resistance for two common string sizes. Fig. 5, which is applicable to 5½-in. casing, will be used to illustrate this effect.

3. Assume setting depth — 6860 ft.

4. Tensile load would be (9000-6860) 17 = 36,000 lb (to nearest thousand).

5. A tensile load of 36,000 lb applied to 15.5 lb J pipe results (according to Fig. 5) in an effective collapse resistance of 3600 psi or safe setting depth of 6400 ft for standard design conditions.

6. New assumed setting depth — 6400 ft.

7. Tensile load (9000 — 6400) 17 = 44,000 lb.

8. From Fig. 5 with 44,000-lb tensile load, the effective setting depth is 6230 ft.

9. New assumed depth is 6230 ft.

10. Tensile load is (9000 — 6230) 17 = 47,000 lb (to nearest thousand).

11. From Fig. 5 — 6200 ft. When calculated depth is within 50 ft of assumed depth, consider calculated value as changeover point. Tensile load is (9000 — 6200) 17 = 47,600 lb.

12. Final check is to determine the joint type. From Table 1, short coupling strength for 17-lb casing is 273,000 lb. Allowable load on top joint is 273,000/1.8 = 152,000 lb. Actual load is 47 600 lb therefore short coupling is satisfactory. This completes design for Section A.

Section B — 6200 ft to ?

1. Section B will be made up of 15.5-lb J casing.

2. What is the length and what type coupling will be used?

3. Next lightest casing is 14.0-lb J. Its safe setting depth is 5640 ft if no tensile load is applied.

4. Assume 5640 ft is setting depth.

5. Tensile load on bottom of 14.0-lb casing will be 47,600 lb of 17-lb casing + (6200 — 5640) 15.5 = 47,600 + 8700 = 56,300 lb.

6. From Fig. 5 for 14.0-lb J casing, 4900 ft is safe setting depth for 56,000-lb load.

7. Assume 4900 ft as safe seting depth, then tensile load is 47,600 + (6200 — 4900) 15.5 or 68,000 lb.

8. New setting depth (Fig. 5) — 4750 ft.

9. Tensile load — 47,600 + (6200 — 4750) 15.5 = 70,000

10. New setting depth (Fig. 5) 4650.

11. Tensile load — 47,600 + (6200 — 4650) 15.5 = 72,000.

12. New setting depth — 4625 ft. This is satisfactory.

13. Ultimate joint strength of 15.5-lb J short coupling is 211,000 lb.

14. Maximum allowable tensile load on top 15.5-lb joint is 211,000/1.8 = 117,200 lb.

15. Actual tensile load is 47,600 + (6200 — 4625) 15.5 = 72,000 lb. Therefore short coupling is satisfactory.

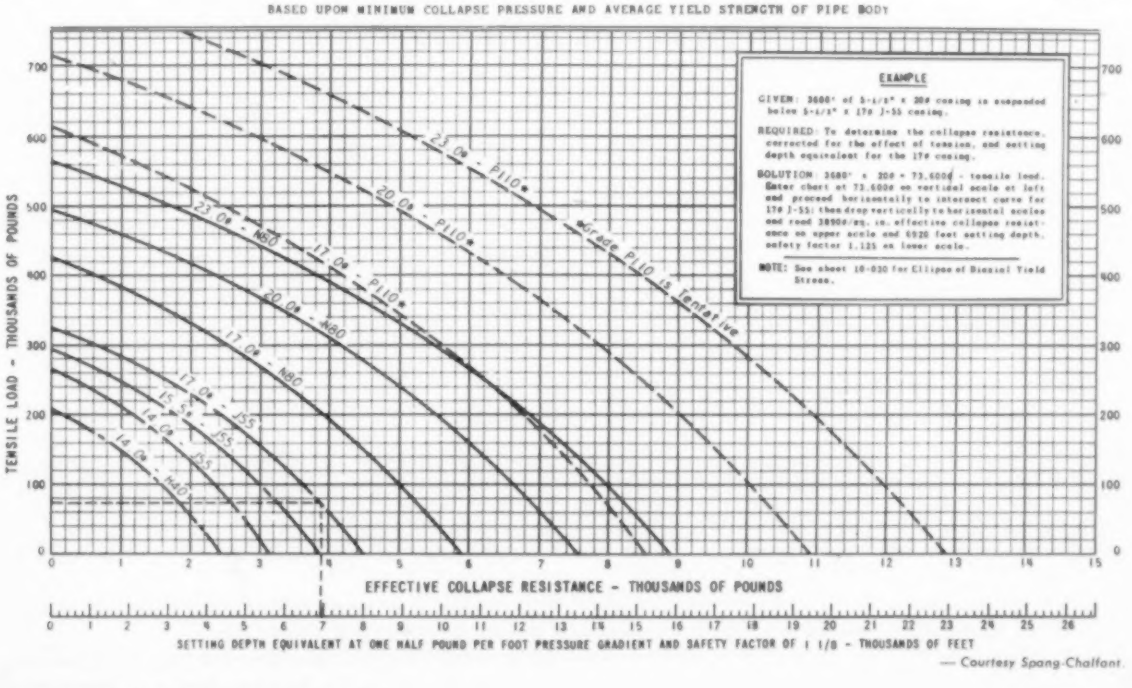
Section C — 4625 ft to ?

1. Section C will be made up of 14.0-lb J casing.

2. Next lightest casing is 13.0 F but this casing only has a 95,000-lb ultimate joint strength (Table 1) or maximum allowable strength of 95,000/1.8 = 52.800 lb, which is not large enough to support even the 15.5 J and 17.0 N casing used in this problem.

3. How high can the 14.0 J casing be extended? Above 4625

5½" OD — FIG. 5. Effect of Tensile Loading on Casing Collapse. — 5½" OD


BASED UPON MINIMUM COLLAPSE PRESSURE AND AVERAGE YIELD STRENGTH OF PIPE BODY
EXAMPLE
GIVEN: 3680' of 5-1/2" x 20# casing is suspended below 5-1/2" x 17# J-55 casing.
REQUIRED: To determine the collapse resistance, corrected for the effect of tension, and setting depth equivalent for the 17# casing.
SOLUTION: 3680' x 20# = 73,600# - tensile load. Enter chart at 73,6000 on vertical scale at left and proceed horizontally to intersect curve for 17# J-55; then drop vertically to horizontal scales and read 38900/sq. in. effective collapse resistance on upper scale and 6920 feet setting depth, safety factor 1.125 on lower scale.
NOTE: See sheet 10-030 for Ellipse of Biaxial Yield Stress.
23 Os - P110
20 Os - P110
23 Os - N80
17 Os - P110
20 Os - N80
17 Os - N80
17 Os - J55
15.5 Os - J55
14 Os - J55
14 Os - N80
Grade P110 is Tentative
TENSILE LOAD - THOUSANDS OF POUNDS
EFFECTIVE COLLAPSE RESISTANCE - THOUSANDS OF POUNDS
SETTING DEPTH EQUIVALENT AT ONE HALF POUND PER FOOT PRESSURE GRADIENT AND SAFETY FACTOR OF 1 1/8 - THOUSANDS OF FEET

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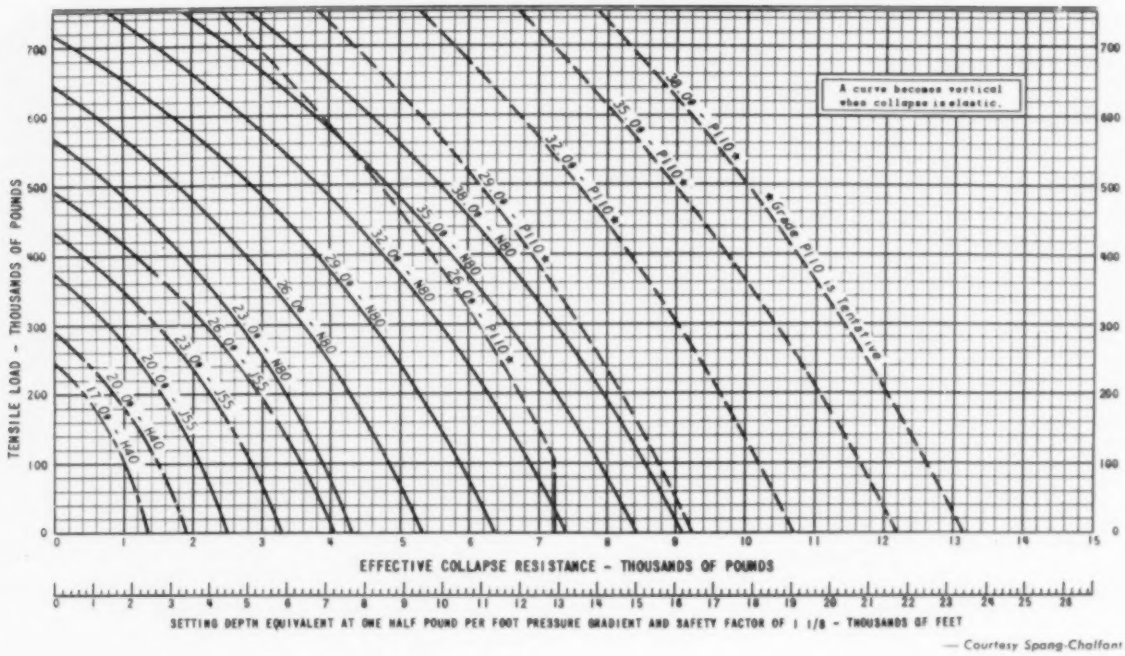
7" OD

FIG. 6. Effect of Tensile Loading on Casing Collapse.

7" OD

BASED UPON MINIMUM COLLAPSE PRESSURE AND AVERAGE YIELD STRENGTH OF PIPE BODY


A curve becomes vertical when collapse is elastic.
Grade P-110 is tentative
TENSILE LOAD - THOUSANDS OF POUNDS
EFFECTIVE COLLAPSE RESISTANCE - THOUSANDS OF POUNDS
SETTING DEPTH EQUIVALENT AT ONE HALF POUND PER FOOT PRESSURE GRADIENT AND SAFETY FACTOR OF 1 1/8 - THOUSANDS OF FEET

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ft it is safe from collapse (the previous calculations showed this), therefore check its tensile limitations.

4. Allowable tensile load is 186,000/1.8 = 103,000 lb.

5. 103,000 — 72,000 (weight of casing below 14 lb per ft) = 31,000 lb of 14-lb casing allowable.

6. $\frac{31{,}000 \text{ lb}}{14 \frac{\text{lb}}{\text{ft}}} = 2210$ ft of 14-lb casing.

7. Top of 14-lb J-S casing is 4625 — 2210 = 2415 ft. Some companies limit the number of sections in a string to four.[2] Others place no limit.

Section D — 2415 ft to ?

1. The next heavier casing is 15.5-lb J. The long coupling has an ultimate strength of 247,000 lb or an allowable of 137,000 lb.

2. The weight of the casing below it is 103,000 lb or 34,000 lb of 15.5-lb casing can be utilized. This is $\frac{34{,}000}{15.5} = 2190$ ft or the top of the 15.5-lb J-L is 2415 — 2190 = 225 ft.

Section E — 17-lb J-L

1. Allowable tensile stress — 275,000/1.8 = 152,000 lb

2. Weight below Section E is 137,000 lb.

3. Allowable length of 17 J-L casing is $\frac{(152{,}000 - 137{,}000)}{17}$ = 820 ft which is more than necessary.

This completes the design. A summary plus approximate casing cost (without freight) is given below:

Depth	Type		Approximate Cost
0 — 225 ft	17.0 J-L		$ 418
225 — 2415 ft	15.5 J-L		3767
2415 — 4625 ft	14.0 J-S		3338
4625 — 6200 ft	15.5 J-S		2583
6200 — 9000 ft	17.0 N-S		5852
		Total	$15,958

Cost of the comparable single weight and grade casing string in Example 5 is $18,810. A saving (not including freight saving) of about $2852 or 15.2 percent was accomplished by the combination string design.

EXAMPLE 7. 7-in. casing is to be set to 7390 ft: 10.2 lb per gal mud will be used. It is not expected that bursting pressure will exceed 3000 psi. Experience in the area indicates that safety factors of 1.1 for collapse and internal pressure and 1.5 for tension are satisfactory. Design a combination string.

Section A — 7390 ft to ?

1. Maximum collapse pressure — Fluid pressure (10.2 lb per gal) — 0.529 psi per ft (Table 6). Maximum collapse pressure 7390 × 0.529 = 3900 psi.

2. Section A casing must withstand 1.1 × 3900 = 4290 psi. Table 1 indicates that for 7-in. casing, 23 N has a collapse resistance of 4300 psi which is satisfactory for collapse. At what point above 7390 ft can the next lighter casing (20 J) be used?

3. 20 J casing has a collapse resistance of 2500 psi. It can be safely stressed to $\frac{2500}{1.1} = 2270$ psi. With this collapse stress the allowable setting depth is $\frac{2270 \text{ psi}}{0.529 \frac{\text{psi}}{\text{ft}}} = 4300$ ft providing there is no tensile load on the bottom.

4. Tensile load on bottom of 20 J casing would be (7390-4300) 23 = 71,000 lb.

5. For this load, Fig. 6 shows collapse resistance of 20 J is 2200 psi. Allowable setting depth, considering safety factor and mud pressure is $\frac{2200}{1.1} \times .529 = 3790$ ft.

Tensile load if 3790 is setting depth is (7390 — 3790) 23 = 82800 lb.

6. For this load, collapse resistance of 20 J is 2175 psi (Fig. 6). Allowable setting depth is $\frac{2175}{1.1} \times .529 = 3740$ ft. This is within 50 ft of assumed value (3790 ft) therefore, the changeover point from 23 N to 20 J casing will be set at 3740 ft.

7. The tensile load on the top of the 23 N section is (7390 — 3740) 23 = 84000 lb. Ultimate strength of the short 23 N coupling is 350,000 lb. Allowable load is $\frac{350000}{1.5} = 233{,}000$ lb which is greater than expected 84,000 lb.

8. Section A will extend from 7390 to 3740 ft and will consist of 7-in. 23 N — ST&C.

9. Internal Pressure allowable is $\frac{6340 \text{ psi}}{1.1} = 5770$. This is greater than 3000 psi expected maximum therefore above specification is satisfactory for collapse, tension, and internal pressure.

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Case History of 2 Wheland HP-18000 Pumps:
No. 1—Excellent performance on 112,000' of hole.
No. 2—Seven wells completed since March, 1956.

Here is the second Wheland HP-18000 Pump purchased by Bilbo-Redding, shown on location at Cleveland, Texas. Their first pump's record was so good, this one was put in service 11 months later.

PERFORMANCE SOLD THE SECOND PUMP

"... exceptional performance ... operated with ease at all pressures within their ranges ... required little maintenance."

WHELAND HP-18000 DUPLEX SLUSH PUMP

7¾" x 18", 750 HP Nominal Input at 60 RPM. Discharge Pressure with 7¾" liner, 1322 PSI; with 5½" liner, 2700 PSI.

BULLETIN ON REQUEST

Just bought their 3rd HP-18000!

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POST OFFICE BOX [illegible]

Mr. Gordon M. Street, President
The Wheland Company
Chattanooga, Tennessee

Dear Mr. Street:

The Wheland HP-18000 750 HP Pump we bought from you in May of 1955 went immediately into service in the Texas Gulf Coast and has given excellent performance on 112,000 feet of hole.

This pump's record was so good that we put a second one into service early in March of this year. We have already completed 7 wells in the Gulf Coast area using the second pump.

Both of these pumps have given exceptional performance, have operated with ease at all pressures within their ranges and have required little maintenance.

Sincerely yours,

BILBO-REDDING DRILLING CO., INC.

T. P. Bilbo

T. P. Bilbo, Vice-President

TPB:da

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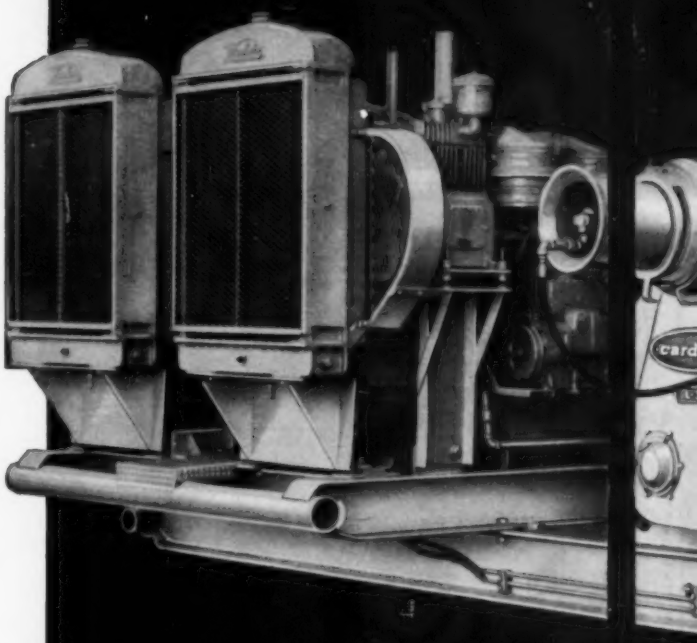

The new Cardwell L-350 is a compact single or twin engine draw works using plate frame construction to achieve a high strength-to-weight ratio. All drives are oil bath lubricated for longer chain life. Here's an extremely versatile unit that is readily adaptable to various trailer mountings as well as conventional skid masts. Single lever controls are centralized in a forward mounted control panel. The safety factor is increased by allowing the driller full view of all drilling operations. An optional sand line drum is offered that does not require any main frame changes. The Model L-350 has a nominal horsepower rating of 350.

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- CHAIN DRIVES—all oil bath lubricated.
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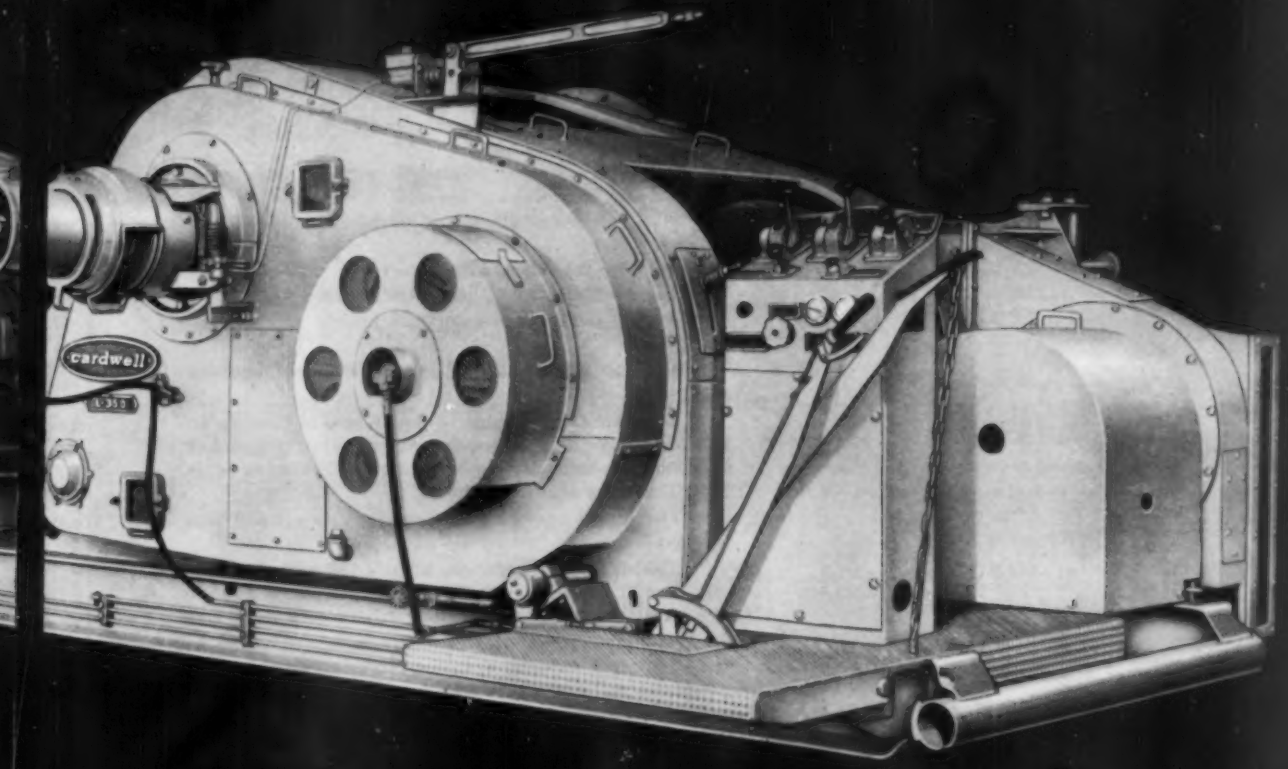
- ROTARY BRAKE—Air Controlled—quickly and smoothly stops and holds rotary table.



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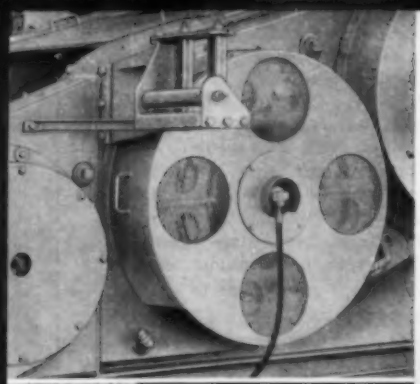
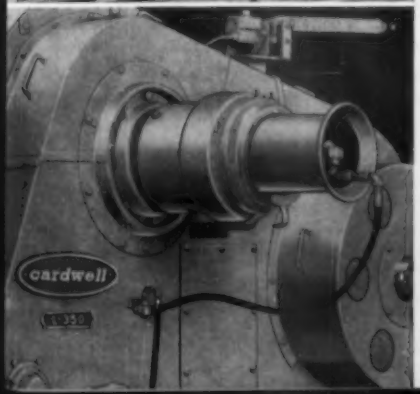


Externally mounted clutches

Maximum operating efficiency is provided by Fawick VC (ventilated type) clutches mounted in each end of a Double End Drum Drive.



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C-4-3

Section B — 3740 ft to ?

1. The weight and grade of Section B is 20 J (from previous work). At what depth above 3740 ft will the next change occur.

2. The next lighter casing is 17 H. Note that the ultimate joint strength is 160,000 lb, which means that it can support only 160000/1.5 = 107,000 lb when the safety factor is considered.

3. How deep can the 17 H casing be set? Allowable setting depth $\frac{1370 \text{ psi}}{1.1 \times 0.529 \frac{\text{psi}}{\text{ft}}} = 2360$ ft (without any tensile load).

4. Tensile load at 2360 ft is 84,000 lb + (3740 — 2360) 20 = 110,800 lb. This exceeds the allowable tensile stress therefore the 17 H casing cannot be used.

5. How far can the 20 J pipe be extended?

Ultimate strength is 254,000 lb. Allowable load is $\frac{254{,}000}{1.5}$ = 169,000 lb. Weight of 20 J pipe that can be used is 169,000 — 84,000 (weight of 23 N) = 85,000 lb.

Length of 20 J pipe will be $\frac{85\,000 \text{ lb}}{20 \frac{\text{lb}}{\text{ft}}} = 4250$ ft.

6. This length will carry pipe up to surface.

7. Internal pressure resistance is 3740 psi (Min Yield Strength). Allowable pressure is $\frac{3740}{1.1}$ =3400 psi which is greater than expected maximum 3000 psi.

8. Section B therefore will be 20 J-S and will extend to the surface.

Overall specifications are —
0 — 3740 ft — 7-in. — 20 J-S
3740 ft — 7390 ft 7-in. — 23 N-S

Casing Accessories

In addition to the casing itself, other items are necessary to make the handling of casing efficient. For example, in running casing in a hole the elevators and hooks must be strong enough to support the casing. Tongs and slips must be designed so that the danger of scoring and denting will be kept to a minimum.

Some other special appliances are described below:

1. Casing shoes. There are placed at the bottom of the casing to guide casing down and prevent it from sticking.

2. Float shoe. This is a small joint or sub with a ball valve in it. The valve prevents backflow from the annulus into the casing, a situation which might occur when cement slurry is pumped through the casing. The slurry which is in the annulus after the cementing operation is followed by mud in the casing and has a greater density than mud. The larger annulus pressure resulting from this is responsible for the backflow tendency.

3. Float collar. It is a small joint separating the guide shoe from the float shoe.

4. Casing spider. Is a heavy metal block with a hole in it to hold slips which in turn support the casing, suspended in it.

5. Casing jacks. When casing is stuck and the engine is not powerful enough to move it, jacks (screws or hydraulic) are used for unfreezing.

6. Centralizers. There are placed on the casing to keep the casing centered. This prevents sticking and increases the cement job efficiency by lessening the tendency of the cement slurry to channel through the mud.

7. Scratchers. This appliance consists of a ring with flexible steel wires attached to it. When the casing moves (reciprocated or rotated), the scratchers stir the mud and tend to prevent slurry channeling.

Handling and Running of Casing

A casing program necessarily includes a plan for inspection and proper handling. The best design means nothing if the casing is poorly handled or improperly assembled and run. For example, placing a short coupling joint near to top of a string which calls for a long coupling can result in the loss of the casing and the hole. Failure to make up a joint properly could cause a leak which would be expensive to repair. These examples plus many other costly possibilities are reasons why careful attention must be given to all casing operations and why the casing program must include instructions for inspection and handling. The API Recommended Practice: Std 5A, 5B, 5C1 contain detailed information about handling and inspection of casing. Some specific ideas proposed are:

1. Inspection of casing. This will be done at the mill. It should also be checked at the local shipping point and at the well. Check for dents, thread damage, or other inperfections.

2. Measure the casing with a good steel tape and check the grade, weight and coupling before making it up.

3. Record the description of each joint in a permanent record book.

4. Have a drift diameter gage to check any questionable joints.

5. In making up and running pipe lubricate threads, lift and lower carefully, use a uniform makeup torque API suggests three turns beyond hand tight for 7⅝ in. or larger pipe. This is a matter of judgment.

6. Use proper casing accessories such as tongs and slips to avoid damage.

7. Use drill pipe protectors when drilling ahead. Bobo suggested in commenting on Texter's[5] paper that in an abrasive circulating medium wear might be severe even with the rubber protectors.

8. Improper welding on casing can cause severe stressing of casing. N-80 and P-110 casing are especially subjected to strength losses.

9. Casing landing practice. After the casing is made up, cement slurry is pumped through it to the annulus where it sets. The landing procedure is concerned with what should be done with the casing while waiting for the cement setting. The choices are to (1) pull up on the casing, (2) slack off (allow the cement and bottom of the hole to support part of the load), and (3) to leave the casing as cemented which means to keep the casing in the same position it was when cemented.

In the first case, the tension load is increased which decreases the safety factors for both tension and collapse but will tend to prevent buckling caused by longitudinal or axial compression. The second case (slack off) will decrease the tension load which will make the casing less susceptible to collapse and tension failures but more likely to buckle. The third choice is a compromise. As a result of a study[10] of landing practices for the southwestern United States, it was recommended that in general, casing should be landed as set. The API committee further suggests that a detailed stress analysis[11, 12] should be made for cases where unusual conditions (e.g. very deep wells, heavy muds) are expected.

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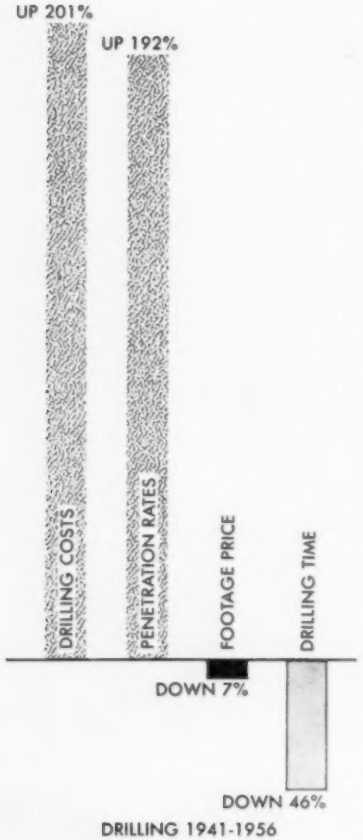
THE RISE — of costs, — penetration rates AND FALL — of footage prices, — drilling time IN CONTRACT DRILLING

Fewer contract drilling rigs are now drilling more hole, in less time, and for less money—a record that cannot long go uncompensated



Fifteen years of contract drilling in the U. S. — a period of change. Total drilling costs have spiraled while footage prices have dropped; penetration rates are up and average drilling time in days is down. These AAODC statistics were compiled for drilling in same or similar fields to comparable depths.

OIL well drilling data and cost statistics released recently by the American Association of Oilwell Drilling Contractors reveal several changes in the contractor's technical and economic situation during 1956.

Brad Mills, executive vice president of the AAODC, said the recently completed study shows that "the drilling contractor completed 93 percent of all wells and again performed a major feat in drilling more wells and footage with fewer rigs at 1944 footage prices."

Mills also pointed out that the 1956 weighted average contract cost of $4.75 represented only 34 percent of the total cost of drilling, which last year averaged $13.75 per ft. In 1944, the contract cost was 57 percent of the total, which includes costs of materials and services bought directly by the oil operator. Contract footage prices have actually fallen, in the face of greatly-increased costs to the contractor.

"It is strongly indicated that drilling costs will increase during 1957," Mills said, "and it is only reasonable to assume that contract footage prices will be advanced to absorb this rise."

Drilling Highlights

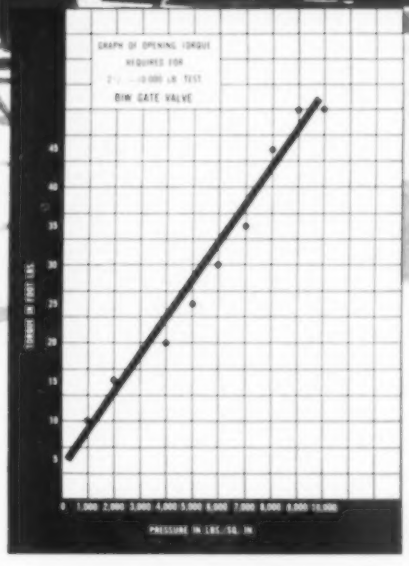
● Faster drilling times were recorded in 1956. Rate of penetration showed marked improvement over the previous year, and was up 192 percent over the 1941 rate.

United States Contractor Drilling Trends.

	Total New Wells Completed	Total Footage Drilled	Average Depth Per Well	INDICATED WORK BY CONTRACTORS Percent	New Wells Completed	Footage Drilled
1935	24,851	67,844,939	2760	68	16,899	46,134,559
1936	28,962	80,996,816	2797	69	19,984	55,887,803
1937	35,213	105,099,189	2985	71	25,001	74,620,424
1938	29,127	90,585,158	3110	71	20,680	64,315,462
1939	28,012	85,523,094	3053	70	19,608	59,866,166
1940	31,149	96,182,605	3088	71	22,116	68,289,650
1941	32,510	99,347,714	3056	72	23,447	71,503,354
1942	21,990	67,903,053	3088	70	15,393	47,532,137
1943	20,349	61,991,857	3046	75	15,262	46,493,893
1944	25,786	84,378,457	3272	78	20,113	65,815,196
1945	26,649	92,982,113	3489	80	21,319	74,385,690
1946	30,230	101,124,813	3345	81	24,486	81,911,099
1947	33,147	112,816,124	3404	81	26,849	91,381,060
1948	39,477	136,709,153	3463	82	32,371	112,101,505
1949	38,962	138,616,941	3558	85	33,119	117,824,400
1950	43,204	159,393,997	3689	88	38,020	140,266,717
1951	44,196	173,315,000	3896	90	39,776	155,984,000
1952	45,879	186,389,000	4060	91	41,750	169,614,000
1953	49,279	197,920,000	4016	91	44,844	180,107,200
1954	53,650	215,940,250	4025	92	49,358	198,665,030
1955	56,850	229,901,400	4044	92	52,302	211,509,288
1956*	58,271	234,350,550	4022	93	54,192	217,946,012

*Estimated

No Grunt, No Cheater, No Strain



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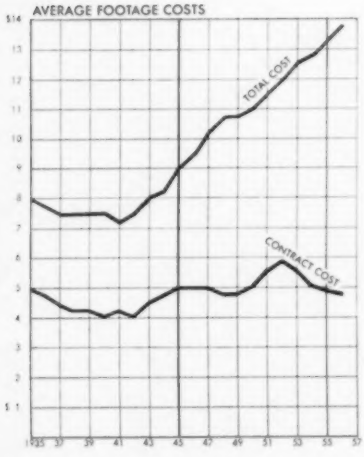
Monthly Average of Rotary Rigs Actually Running in United States and Canada.

Month	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956
January	787	729	1327	1738	1696	1548	1980	2090	2021	2244	2945	2682	2638	2815	2842
February	756	773	1356	1714	1521	1594	1919	2021	1972	2169	2885	2624	2649	2657	2705
March	720	810	1399	1700	1449	1618	1912	2085	2031	2287	2872	2629	2705	2749	2872
April	750	829	1452	1715	1501	1633	2070	2130	2091	2442	2917	2672	2754	2750	2803
May	789	869	1517	1790	1479	1686	2189	2181	2145	2578	3007	2700	2677	2773	2906
June	795	935	1599	1743	1511	1806	2251	2109	2277	2647	2964	2812	2656	2908	2998
July	861	1036	1665	1730	1515	1896	2302	2027	2295	2740	2658	2788	2632	2906	2867
August	833	1105	1710	1730	1552	1947	2348	2022	2304	2867	2505	2793	2551	2941	2775
September	789	1156	1754	1756	1639	1978	2335	2001	2297	2937	2585	2796	2474	2966	2777
October	788	1231	1808	1762	1683	2044	2372	2039	2438	3040	2709	2880	2531	2963	2788
November	788	1293	1849	1796	1674	2056	2437	2197	2500	3008	2835	2941	2713	3058	2822
December	816	1353	1800	1760	1700	2008	2385	2247	2481	3137	2896	2988	2908	3188	2993
Average	788	1009	1603	1744	1576	1817	2208	2096	2238	2683	2816	2777	2657	2873	2846



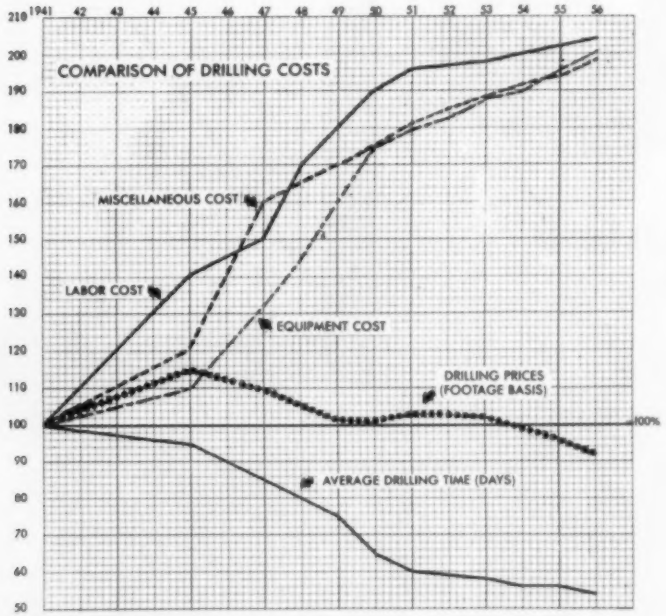
Gap between total drilling costs, borne by the operator, and the average total cost per foot, as charged by the drilling contractor, has steadily widened in the past 21 years.

- A total of 58,281 new wells were completed in the U. S. last year, up 1421 over 1955. Total drilled footage was 234,350,550. This figure, divided by total number of wells, shows that average well depth was somewhat less than in 1955—4022 ft, compared with 4044.

- Average contract cost per foot fell from $4.90 in 1955 to $4.75. There has been a steady decline since the $5.85 mark of 1952. On the other hand, total cost of drilling has gone up in the same period from $12.00 to $13.75.

- Contractors drilled 93 percent of all U. S. wells, 54,192 wells and 217,946,012 ft of hole.

- Average number of rotary rigs running in the U. S. and Canada in 1956 was 2846, 27 short of the mark set in 1955. The steel situation, strikes and shortages, cut rig activity sharply following the June peak of 2998. ★ ★



Drilling costs have followed a definite, upward pattern since 1941. Notice that the pattern is the same. Results of competitive cost cutting, better drilling techniques, "smoother operations," is shown by decreased drilling time and footage price, completely out of proportion to cost curves.

Creole Makes Movie – "Assignment: Venezuela"

A new film, "Assignment: Venezuela," — produced by Creole Petroleum Corporation, Venezuelan affiliate of Standard Oil Company (New Jersey), has been released for U. S. audiences at a premiere held recently at the Johnny Victor Theater in New York.

The motion picture is a 24-minute sound film in color which depicts the life of a young petroleum engineer from the United States who takes an assignment with Creole in Venezuela. It not only shows how he adjusts to his work in a foreign country, but also illustrates much of the environment of his new "home" — including many of the highlights of Venezuela's cultural and economic way of life.

"Assignment: Venezuela" supplements "People and Petroleum," a black and white motion picture released last year by Creole as a documentation of the economic development of Venezuela and the part played therein by the oil industry.

This new picture is Creole's first color film for U. S. audiences, and it will be widely distributed to television stations, civic groups, women's organizations and other non-theatrical outlets. Distribution of both films will be made through Sterling-Movies U. S. A. for television showings, and through Modern Talking Picture Service for adult groups and other non-theatrical audiences.

The film was produced for Creole by Sound Masters Inc.

University of Oklahoma Holds Subsurface Geology Symposium

School of Geology of the University of Oklahoma held its fifth biennial symposium on subsurface geology on March 12-13 in Norman. Theme of the meeting was carbonate reservoirs.

Among topics listed for presentation were carbonate reservoir evaluation, new logging approaches, radioactivity logging in Mid-Continent areas, well completions, exploration. Several addresses were included on geological analyses of limestone reefs and various formations in Texas and Oklahoma.

Carl A. Moore was symposium chairman.

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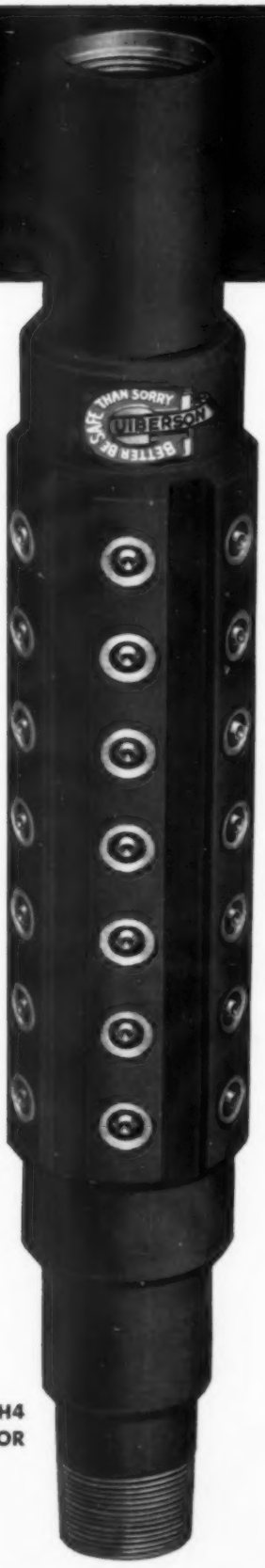

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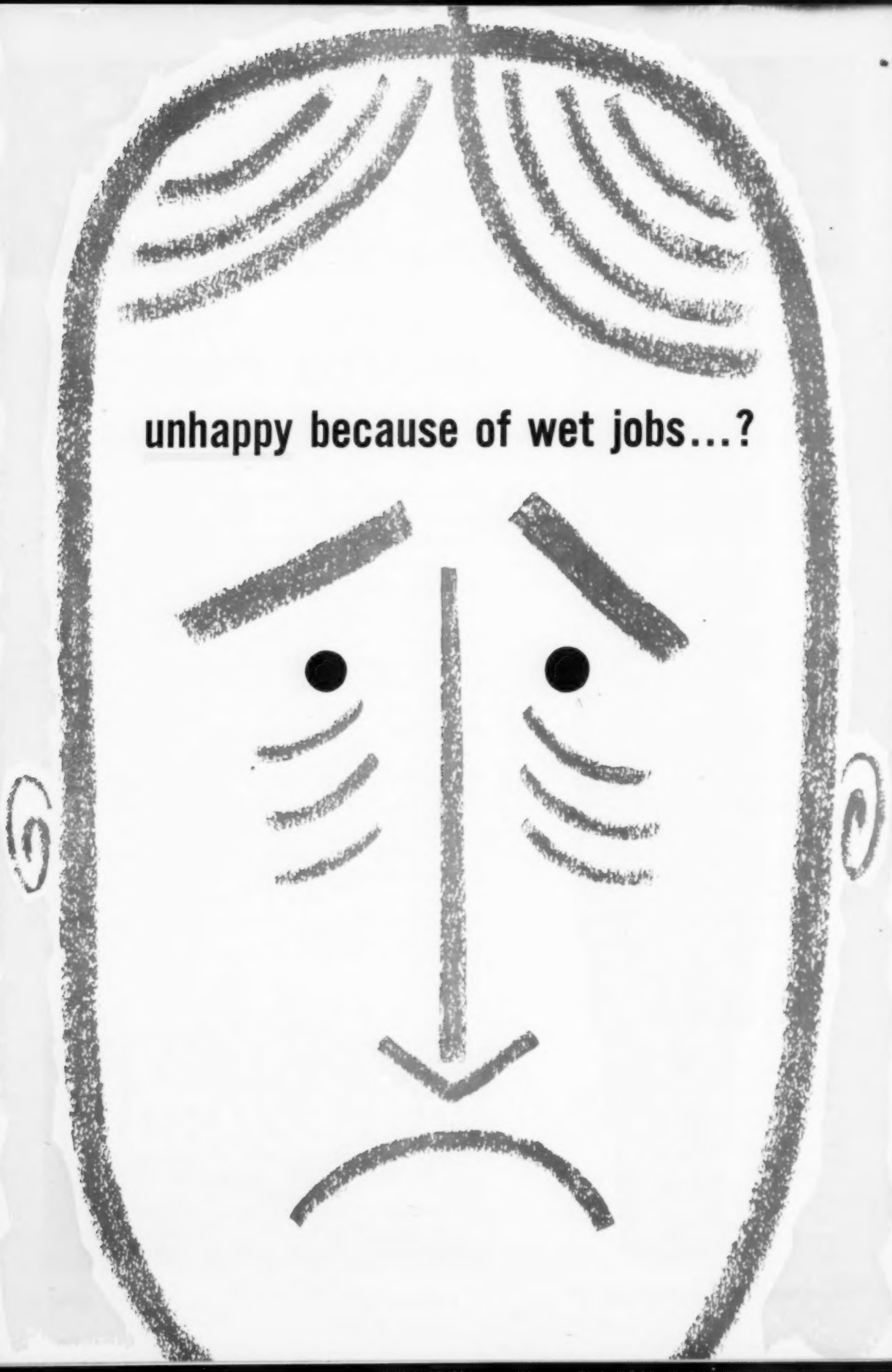
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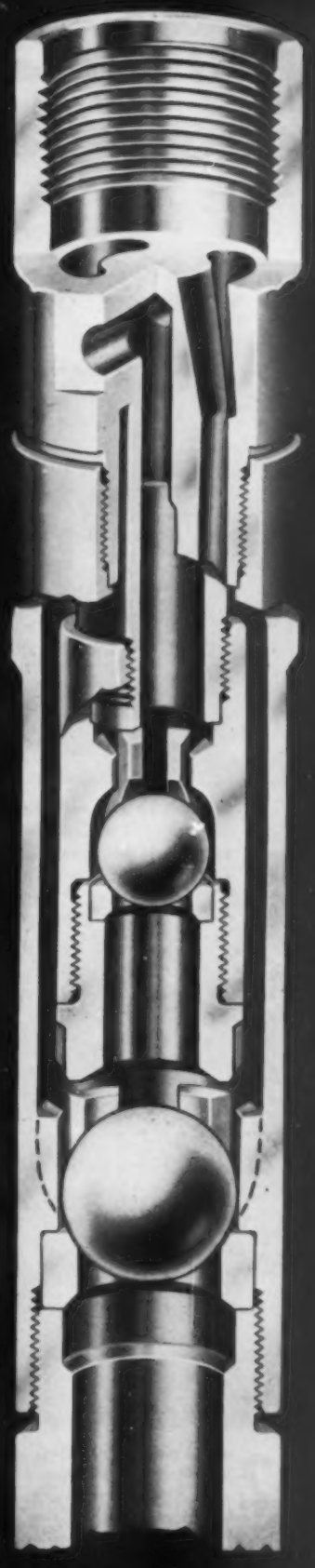

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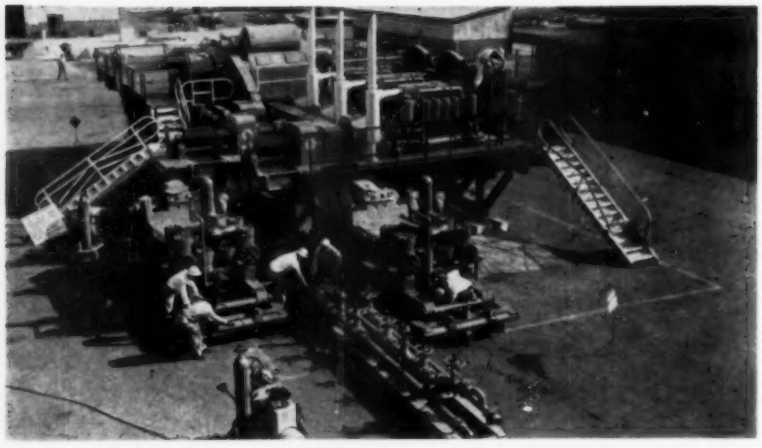

1 **Complete rig — minus mast —** took 16 days to assemble in the plant yard. This Chile-bound rig is receiving final touches. Seven men are seen here painting, tightening, leveling and making final connections. After everything was in place, rig was tested, dismantled for shipment.

DRILLING rigs to be used in foreign operations are usually rigged-up at the manufacturing plant prior to shipping. Purpose of the pre-assembling job is to minimize the time and effort required on location when drilling crews reassemble the rig for operation. With such a start, actual field rig-up may require one, two, or three days.

Pre-assembling was recently completed on a 12,000 ft rig to be shipped to the Corporation de Fomento de la Producion, for use in the Punta Arenas area of Chile. The project consumed 16 days of work from start to finish. Not only were major components positioned, but also all detailed sections fitted together to operate at maximum efficiency as a complete unit. The entire rig, when being dismantled, must be broken into easily movable sections.

What's the procedure for pre-assembling a rig? First, start with a flat space (Fig. 2); then move in equip-

2 **First day of rigging-up job.** Component parts for the rig came from many manufacturers located in several different states. A 30-ton crane is used here to position and level one of the substructure sections.

3 **Drawworks, rotary and drive group** are in position and slush pump cradles have been put in place. A second crane is being used to assist lifting operations. This was the eighth day of the pre-assembly job.

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4 **Ninth day of pre-assembling.** The two cranes work together in lowering a slush pump onto its cradle. Eight-man rig-up force included a working leadman, three mechanics, two welders, an engineer.

5 **Plumbing job deluxe —** a part of every rig-up job. Once these mud, water, air and oil lines are in place, they remain there, saving weeks of difficult work each time the rig is reassembled in the field.

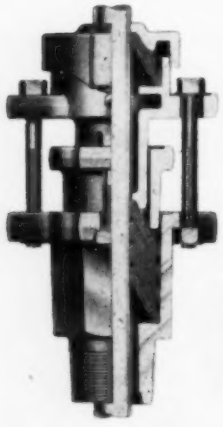
ment on trucks and position it with boom cranes (Fig. 3 and 4).

Much of the detailed work, however, is hardly noticeable, or is taken for granted by the untrained observer.

Mud, water, and oil lines are installed, and hoses, valves, and other fittings are compactly and methodically arranged within and beneath the substructure (Fig. 5).

Acknowledgment

Photographs and material are presented through the courtesy of National Supply Company. Rig assembled for shipment is a National Type 80-B.



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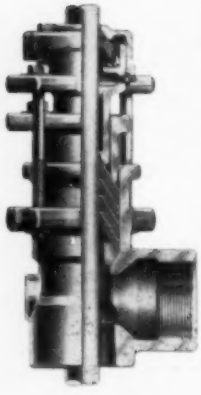

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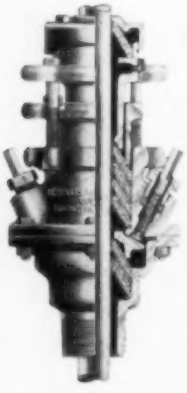

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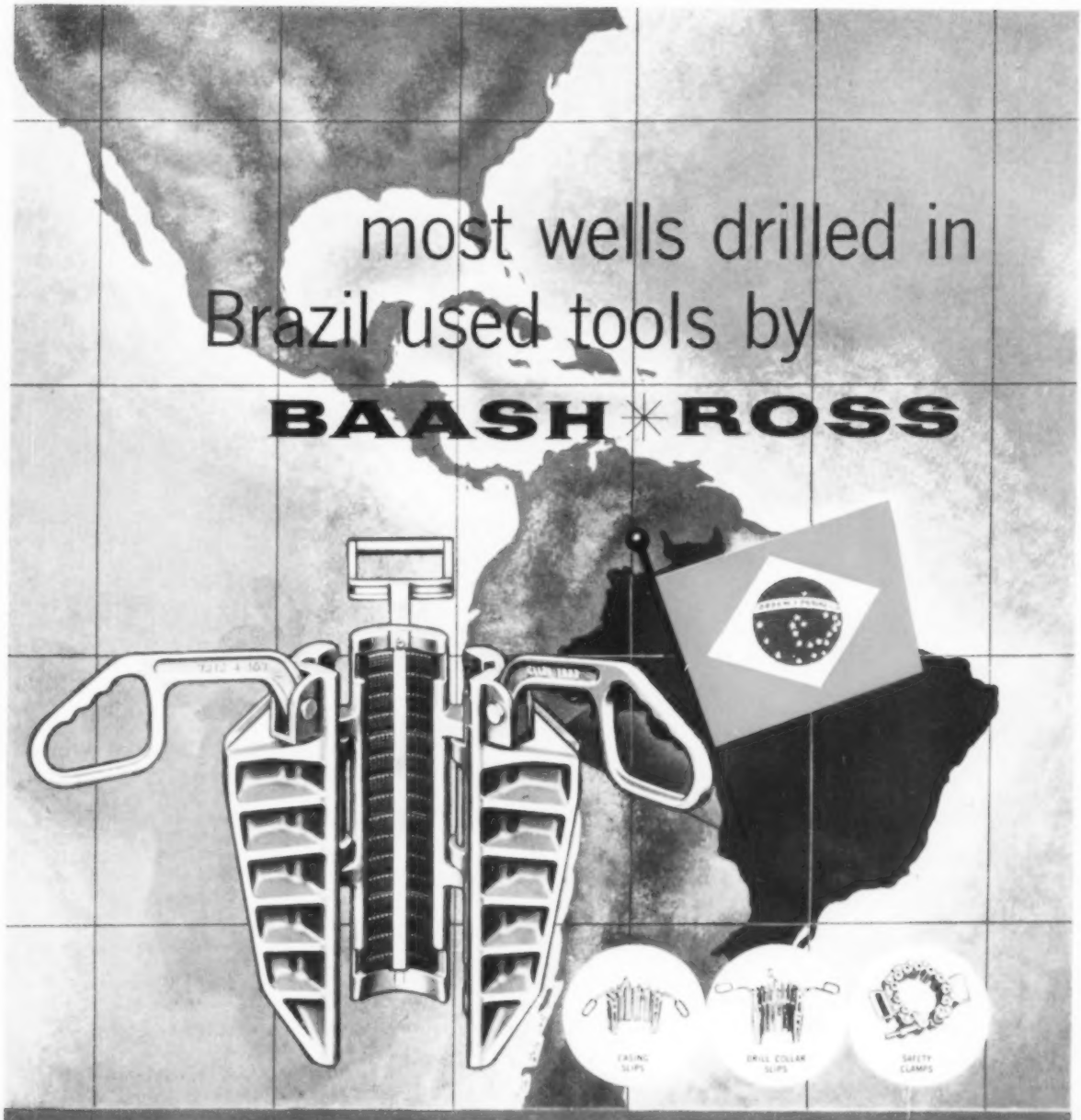

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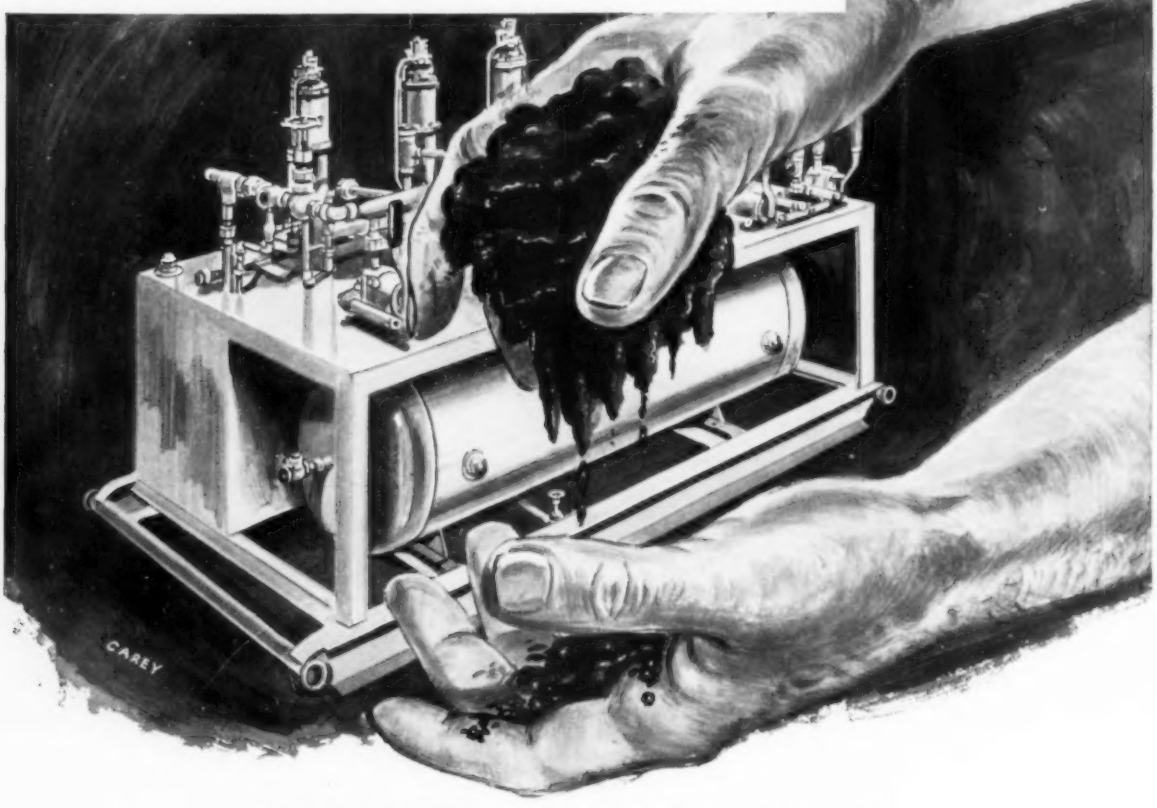

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Income Tax Aspects Of Secondary Recovery Projects

Waterfloods, field unitizations, partnership agreements put new "hitches" in already vague income tax laws concerning oil and gas production. Here's fresh thinking designed to make the most of the tax dollar

A. E. Aikman,
Attorney
Locke, Locke & Purnell
Dallas, Texas

THAT secondary recovery projects and operations are becoming more numerous and important in the oil and gas industry is well known. Unless such projects and operations are undertaken a substantial amount of reserves will be unrecoverable and lost at least as far as this generation is concerned and perhaps to all future generations. As the industry undertakes more of the projects, it is evident that new concepts and techniques are developed to cope with the various problems involved.

Lawyers especially are cognizant of the fact that the development and changes in the law have a tendency to lag behind the development and changes in business operations and procedures which are necessitated by our dynamic economy. And, as so often happens, the laws, whether statutory law or case law, do not give a great deal of assurance as to the ultimate legal consequences stemming from a particular operation, transaction or contract. Particularly, it must be recognized that to determine, with any degree of accuracy, the precise income tax consequences of the formation and operation of secondary recovery projects is to a great extent a matter of judgment, or, if you please, a "weighed" guess. It must also be recognized that desired tax consequences can often be more nearly assured by the form in which the transaction is cast without appreciably affecting the operation or desired economic results.

Just as the nature of the operation of secondary recovery projects vary from project to project, so too, the form of the agreements legal-wise as well as the tax consequences vary from project to project. There are certain fundamentals, however, which are applicable in one manner or another, to similar types of projects. It is the purpose of this paper to consider some of the income tax problems which are more or less common to some of the standard type projects.

PROBLEMS OF ENTITY

Association Taxables as a Corporation

Many secondary recovery projects involve the unitization of the properties with which the project is concerned, although this is not always the case. When properties of several operators are unitized, there is always lurking the problem of whether an association is created which will be taxed as a corporation![1]

If a new taxable entity is formed then an additional corporate income tax is due upon the "taxable income" of the "corporation." Consequently, it is prudent to avoid creating such an association.

The area of associations taxable as corporations is a fuzzy one, and the lines of demarcation, if any, are somewhat obscure. Neither statutes, regulations nor decided cases give any appreciable satisfaction.

The Internal Revenue Service several years ago in two rulings[2] expressed its thoughts on the question insofar as oil and gas joint operating agreements are concerned. These sought to draw a line between "taxable" and "non-taxable" operating agreements. While these rulings are not law, they are helpful if for no other reason than the psychological effect in feeling secure that the Service will not attack the agreement if its rulings are complied with.

IRS position I.T. 3930[2a] states the present position of the Internal Revenue Service, and contends that the four essential requisites to classify an unincorporated organization as an association taxable as a corporation for federal income tax purposes are:

(1) There must be associates.
(2) The object of the organization must be joint profit.
(3) There must be a continuity of life.
(4) There must be centralized control of group affairs.

The ruling then states that the joint operating agreements, then under consideration, meet three of the requisites — that (1) there were associates, (2) there was continuity of life irrespective of the death of a party or transfer of a party's interest, and, (3) there was centralized control of group affairs. Inasmuch as each party had the right to take in kind, however, and separately dispose of, his share of the production the Bureau was of the opinion that there was no "joint profit" objective, then the agreements did not constitute a corporation for federal income tax purposes.

The ruling also stated that "where agreements irrevocably vest the operator in his representative capacity with the authority to extract and sell the mineral, there are created for income tax purposes associations taxable as corporations . . ." This language caused some consternation so the Bureau "clarified" its position by issuing I.T. 3948.[2b] In essence the latter ruling said if a person had irrevocable authority to sell for two or more co-owners, a corporation existed. However, to temper its position, as had been stated in the

former ruling, the Bureau in I.T. 3948 provided:

"Discretionary authority terminable at will granted to a person or persons representing two or more co-owners to enter into contracts committing the principals for such reasonable periods of time as are consistent with the minimum needs of the industry under the circumstances, but not to exceed one year, will not be regarded as inconsistent with revocable representatives capacity in the sense that the term is used herein and in I.T. 3930."

Significance of these Bureau rulings can be seen in almost every joint operating agreement and unit operating agreement in existence today.

Operating agreements generally provide that each operator has a right to take, and to separately dispose of, his share of the production.

Sometimes the pertinent language of I.T. 3948 is included in the agreement to give the operator revocable authority to sell for any or all the owners for such periods of time as are consistent with the minimum needs of the industry but not to exceed one year.

"Subject to Change . . ."

All of this is prudent tax planning. As long as the Internal Revenue Service follows its rulings on operating agreements, we can comply with such rulings and avoid corporation status. However, difficulty may lie ahead. There is no assurance that the Service will adhere to its present position. Consequently, it is this author's belief that sooner or later statutory clarification will be needed if litigation is to be ultimately avoided.

The tax lawyer who works in this area must keep in mind the possibility that the Internal Revenue Service may change its position and litigate the matter; consequently he must endeavor to keep a favorable litigable position as to these agreements if at all possible.

It seems that the Internal Revenue Service has taken a somewhat superficial position on the question. First, it must be remembered that the income tax is a tax upon an entity which **realizes income.** And irrespective of whether the Internal Revenue Service asserts that a taxable entity exists, the alleged entity must nevertheless **realize income** before an income tax can be imposed. In order to realize income, the "taxpayer" must receive something of exchangeable value for its separate use and benefit.[3] Looking at a usual statutory corporation, it clearly appears that the corporation may retain the profits of the business and may use the profits in furtherance of the corporate business without the further individual consent of each stockholder. The corporation has thus **realized income,** and a corporate income tax can be lawfully imposed. Where, however, the proceeds from the sale of products cannot be used in furtherance of any operations for the joint benefit of all the parties to the operation but rather only each participant **alone** has the right to use his share of the proceeds from the sale of his share of the products, then **he alone realizes** the income from such sale and not an alleged intervening entity. This is so, irrespective of whether the operator has irrevocable authority to sell the production for and

The Author

A. E. Aikman is an attorney associated with the Dallas, Texas, legal firm of Locke, Locke & Purnell.

He is a member of the State Bar of Texas and the Council of Mineral Law Section. Aikman is a member of the American Bar Association and is vice chairman of the Tax Division of the Southwestern Legal Foundation. He is well versed on the legal aspects of oil and gas taxation, having served as the tax counsel for the Magnolia Petroleum Company from 1953-1956.

Aikman holds his BA degree from Texas A&M College. He holds the LLB and LLM in Taxation from Southern Methodist University, where he is now a part time lecturer in the School of Law.

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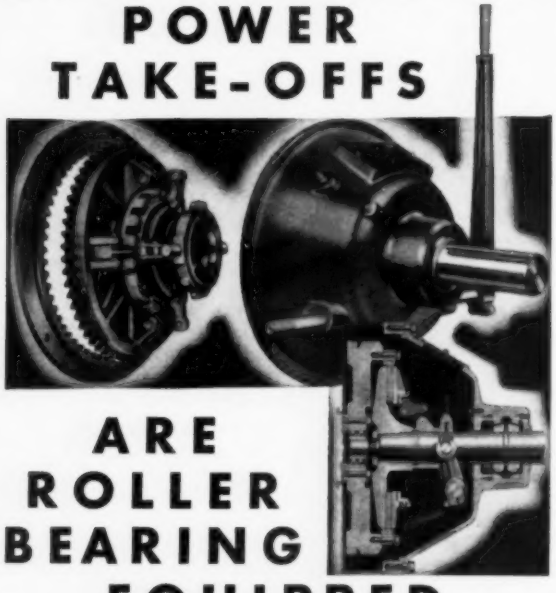

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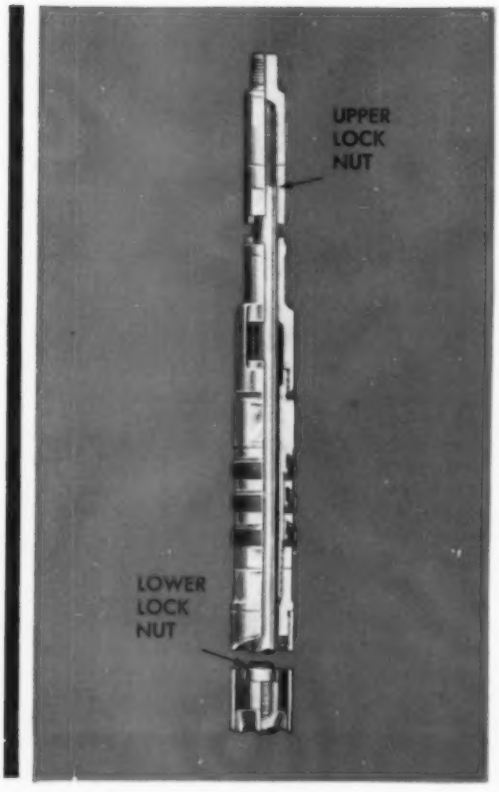

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The doctrine of realization of income deals with the right to use the proceeds from a taxable transaction and not merely the authority to sell.

When these arguments are properly pressed upon the courts, there would seem to be little alternative left to the courts but to follow the arguments. Such an approach would go a long way toward putting at rest the association question.

Not always are the properties involved in a secondary recovery project unitized; rather some form of cooperative agreement is entered into, and such agreements may well, and often do, vary greatly depending upon the circumstances. Generally, each party is entitled to the production from his leases. Usually there is no question but what such agreements do not constitute an association taxable as a corporation, but it is an expense sharing arrangement, pure and simple.

Partnerships for Tax Purposes

Assuming that the secondary recovery agreement clears the hurdle of corporate classifications for income tax purposes, the next question is whether it will be treated as a partnership for income tax purposes, and if so, what can be done to avoid such status.

There is no income tax imposed upon partnerships, as such, as in the case of corporations. Classification of an agreement as a partnership for income tax purposes, however, may well have an adverse and unintended effect upon the income tax liability of some or all of the parties to the agreement.

If a partnership entity is created for income tax purposes, the partnership must compute the net income from operations. It must claim depreciation, depletion, intangible deductions, etc., and make all elections in respect of computation of income,[4] such as an election to expense intangibles.

Moreover, the effect upon the respective parties to the agreement may well be to cause some co-owners to pay higher income taxes than would be the case if they were considered co-owners and not partners. Also, the depletion and depreciation deductions may be substantially lower to some and higher to others. Consequently, it is necessary to determine what the status of the agreement is as respects the partnership provisions of the Internal Revenue Code, and what to do to assure the desired income tax results.

Partnership Ruling

Subchapter K of Chapter 1 of the Internal Revenue Code of 1954 deals with partnerships and partners. Prior to the 1954 code there were few statutory provisions that dealt with partnerships, and they were vague and unsatisfactory. In the 1954 Code many new provisions were added relating to partnerships. These provisions may well be criticized as being vague and unsatisfactory. Nevertheless, we must try to live with them and endeavor to interpret the statutes and regulations as they apply.

Section 761 of the 1954 Code defines the term "partnership" as follows:

> "For purposes of this subtitle, the term "partnership" includes a syndicate, group, pool, joint venture, or other unincorporated organization through or by means of which any business, financial operation, or venture is carried on, and which is not, within the meaning of this title, a corporation or a trust or estate. Under regulations the Secretary or his delegate may, at the election of all the members of an unincorporated organization, exclude such organization from the application of all or part of this subchapter, if it is availed of —
>
> (1) for investment purposes only and not for the active conduct of a business, or
>
> (2) for the joint production, extraction, or use of property, but not for the purpose of selling services or property produced or extracted."

As is apparent, the definition language is very broad and certainly not definitive in any real sense.

Taking the quoted provision altogether, however, it seems clear that the broad definition includes the usual joint operating and unit operating agreement. Under the 1939 Code there was doubt in the minds of many tax lawyers that a joint operating agreement or unit operating agreement was a partnership for income tax purposes, although the Internal Revenue Service was of the opinion that such agreements did constitute partnerships.[5] Court decisions did not clarify the status although the Tax Court in one case rather assumed that a joint operating agreement did constitute a partnership.[6]

Regulations[7] under Section 761 of the 1954 Code state "a joint undertaking merely to share expenses is not a partnership." Many of the cooperative agreements in respect to secondary recovery projects seem to be simply expense sharing arrangements and would appear not to be partnerships for purposes of the federal income tax.

Each such agreement must be analyzed thoroughly, to determine whether it is more than a mere expense sharing arrangement.

The portion of Section 761 quoted above states that certain agreements may be excluded from partnership

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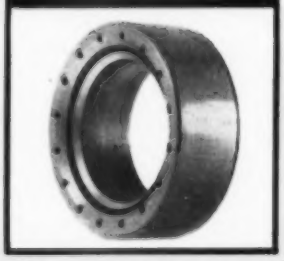
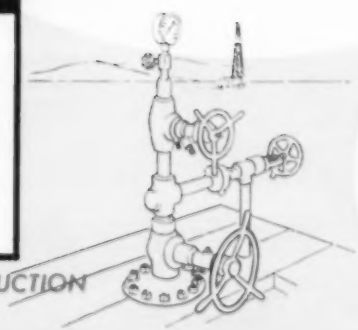
SEATING
Segment of seating core face is hard faced and ground, for spherical seating to resilient body seat.

FULL ROUND OPENING
Available in six sizes, wide working pressure range, carbon or stainless trim, flanged or screw end. Venturi type tubing wing valve for christmas tree service, 2" x 1" only, Flanged end, 4,000, 6,000 and 10,000 lbs. test.

RESILIENT BODY SEAT: A type 416 heat treated stainless steel with Buna N synthetic rubber securely bonded into the annular groove of the seat ring. Tough and corrosion resistant.

CLOSED POSITION





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The metallurgy and heat treating department functions all the way from the raw material to the finished product; as each heat of steel arrives at the plant, pilot bars are tested in the laboratory for required chemistry, and to determine the proper heat treating cycle to assure the best physical properties.

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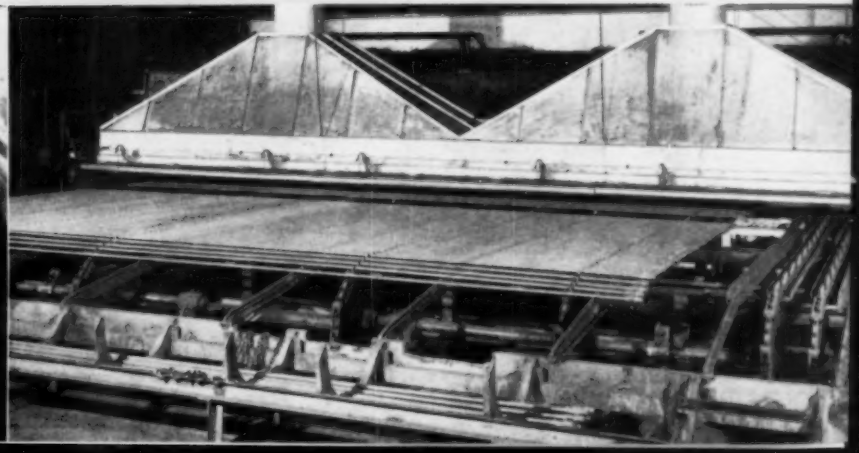
Laboratory pre-testing of sucker rod stock develops optimum heat treating procedures for production control.

Production heat treating furnace with specially designed extra-long cooling bed insures maximum uniformity of grain structure as material is heated above and cools below critical temperatures.



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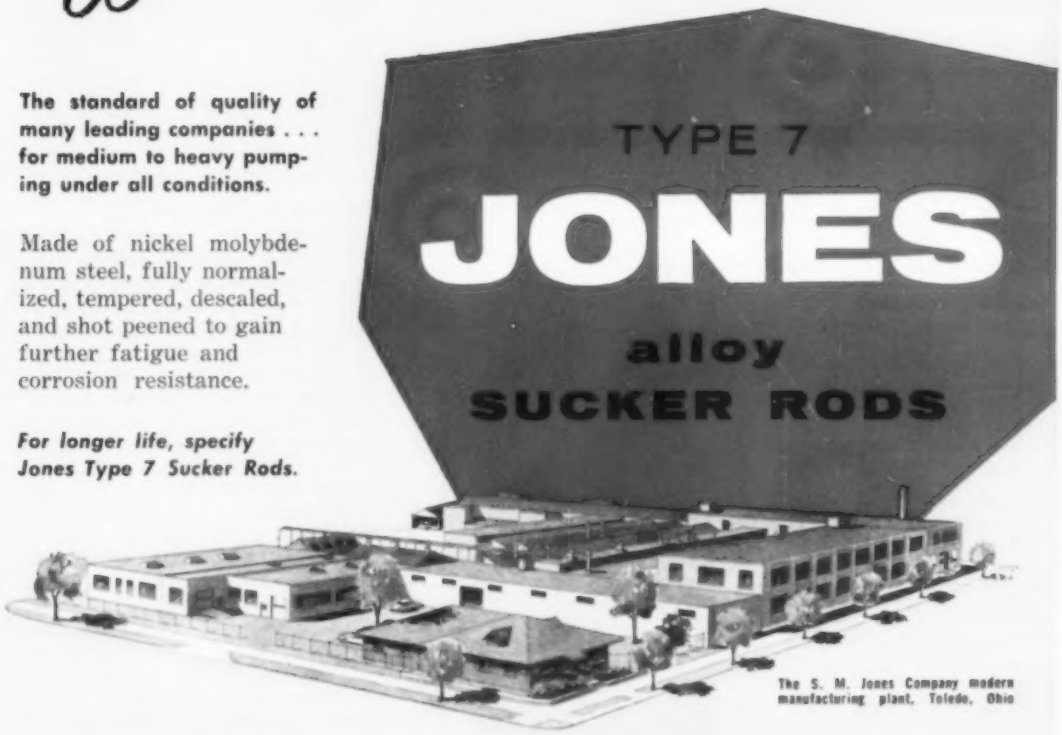
The standard of quality of many leading companies . . . for medium to heavy pumping under all conditions.

Made of nickel molybdenum steel, fully normalized, tempered, descaled, and shot peened to gain further fatigue and corrosion resistance.

For longer life, specify Jones Type 7 Sucker Rods.



The S. M. Jones Company modern manufacturing plant, Toledo, Ohio

FOUR TYPES OF JONES SUCKER RODS FROM WHICH TO CHOOSE

Type	Identification	USE	DESCRIPTION	PHYSICAL PROPERTIES					
				Yield 1000 psi	Ultimate 1000 psi	% Elong. in 8"	% Red. of Area	Izod	Brinell Hardness
J-12	Protector ends painted BLUE	For heavy pumping loads under all conditions	Made from processed electric furnace steel with high yield strength and excellent fatigue resistance.	95-105	110-125	12-17	65-75	90-110	229-260
J-8	Protector ends painted BLACK	For extremely heavy pumping loads	A special alloy steel of exceptional yield strength and well-balanced physical properties.	100-115	120-135	10-15	50-60	65-85	248-388
J-7	Protector ends painted ORANGE	For medium to heavy pumping loads under all conditions	Called "standard of the industry". Strong, corrosion resistant nickle molybdenum steel, fully normalized, tempered, descaled and shot peened for further fatigue and corrosion resistance.	65-80	85-100	14-22	60-70	90-107	170-210
J-2	Protector ends painted WHITE	For medium to heavy pumping loads in non-corrosive fluids	High grade carbon manganese steel, fully normalized, descaled and shot peened to add strength and endurance.	60-75	90-105	18-24	60-70	60-90	160-210

Jones Pony Rods carry the same physicals as Jones Sucker Rods. Always use proved superior Jones Pony Rods with proved superior Jones Sucker Rods.

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two important ways!...

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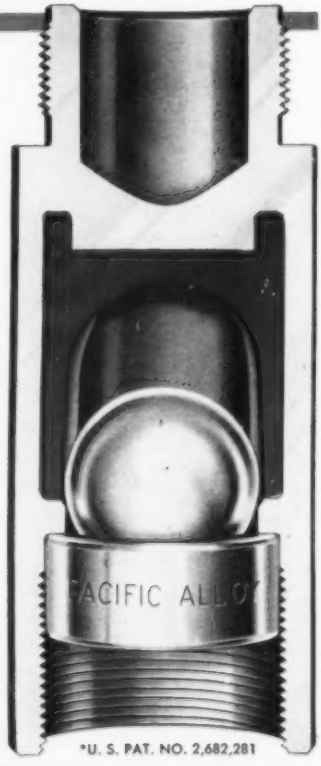
A PACIFIC steel ball valve cage fitted with a flexible, resilient ball valve guide retains its original shape after 182 days of continuous operation. The ball valve is in good condition and may be easily removed from the cage.

A standard steel ball valve cage with hardened steel ball valve guides permanently deformed after 49 days of continuous operation. The ball valve cannot be removed from the cage.



*U. S. PAT. NO. 2,682,281

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treatment if all the members so elect. The pertinent language with which we are concerned is that permitting an election where the organization is availed of —

(1) "for the joint production, extraction, or use of property, but not for the purpose of selling services or property produced or extracted."

The further requirement is that the income of the participants may be "determined without the computation of partnership taxable income."

This is directed specifically to joint operating and unit operating agreements. In the normal unit situation, an election is available to exclude the operation and agreement from partnership treatment for income tax purposes and place the parties in the position which they desire — merely co-owners.

Method for Election

Essentially the regulations provide that the election is to be made by statement attached to the partnership return (Form 1065). This statement must include (a) the names and addresses of all the members of the organization (parties to the operating agreement); (b) state that the agreement qualifies under subdivision (iii) of sub-paragraph (2) of paragraph (a) of Section 1.761-1 of the Regulations; (c) that all the members (parties) elect to be excluded from all of subchapter K; and (d) where a copy of the operating agreement is available, if written, and if oral from whom the provisions may be obtained.

An election to be excluded from partnership treatment may be filed for any year, and once made, shall thereafter be binding as long the "organization" remains qualified or unless approval of revocation of the election is obtained from the Commissioner. If an election is not made the first year, the election is not forever lost; rather the following year an election can be made, or any other subsequent year.

The regulations anticipate that the operator shall file the Form 1065 in making the election. Regulations do permit a non-operator to file, however. If the operator files he shall file with the District Director of Internal Revenue for the district where the operator has his principal office or place of business. On the other hand, where a non-operator files, he shall file with the district director for the district where such non-operator has his principal office or place of business.

Form 1065 is due for a particular year on April 15 of the following year generally. The regulations in this regard provide: "Where no annual accounting period has been adopted by such unincorporated organization, its taxable year shall be the calendar year . . ."

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to save you valuable time and production

All of the working parts — bonnet, stem and gates — may be removed in one simple operation. Seats can be replaced, if necessary, with **W-K-M** 's hydraulic seating tool. Re-assembly, after thorough cleaning, repairing or replacement of parts, is equally easy. When overhauling is completed your **W-K-M** Valve is as good as new—and usually the job takes only an hour.

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Member Consent

Of course, as to many of the agreements where there are many parties, it is impossible to obtain the consent of all such parties, and this fact was recognized by the Commissioner in promulgating his regulations in this regard. It is provided in the regulations that "unless within 90 days after the formation of the organization (or by October 15, 1956, whichever is the later) any member of the organization notifies the Commissioner that the member desires subchapter K to apply to such organization and also advises the Commissioner that he has so notified all other members of the organization by registered or certified mail the election to be excluded will be effective."

Perhaps certain precautions should be taken in reference to electing under Section 761 of the 1954 Code.

First, a partnership must make the election to expense intangible drilling and development costs, and unless a specific election to expense is made the taxpayer is deemed to have elected to capitalize such costs. **It is advisable, as a protective measure, to state in the partnership return (1065) that if for any reason the election to be excluded from partnership treatment is not approved, the organization elects to expense intangible drilling and development costs.**

Also, in order to obviate the possibility of any dissenters to the election to be excluded from subchapter K in respect of agreements hereafter entered into, it is advisable to include in the agreement a provision whereby each and every party agrees to such an election.

Cooperative Agreements

As pointed out, many of the cooperative agreements perhaps do not come within the definition of the term "partnership" although, in some instances, this may be difficult to determine precisely. Therefore, where there is doubt as to whether the agreement is within the general definition of partnership, it is believed the wiser course to follow is to file a Form 1065 and make an election to be excluded from partnership treatment.

Note should be made of the provisions of the regulations relating to the qualifications necessary before the election to be excluded from subchapter K is available. **The organization must not jointly sell services or the property produced or extracted.** The regulations in effect provided that the election to be excluded is not available to "any unincorporated organization one of whose principal purposes is cycling, manufacturing or processing for persons who are not members of the organization."[9] Sometimes unit fa-

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cilities include gas processing plants which serve the unit, and there are instances where gas is processed for outsiders. In those situations, care must be taken to avoid preclusion of the election.

It is the writer's opinion that where gas is purchased by the plant owners from non-owners, and such gas is processed in the plant, this is not "processing for persons not members of the organization." Consequently, where possible the gas should be purchased by the plant owners from the outsiders.

Purpose of the Plant

Assuming that an outsider brings his gas to the plant and the owners process it and retain a portion of the liquids and residue to the owner, which is the situation referred to in the regulations, when does such become a "principal purpose?"

Nothing definitive appears in the regulations, and only the extreme situations are clearly answerable. Many times a lease owner does not have enough gas production to justify building a processing plant, and as a matter of conservation, the owners of a plant do process the non-plant owner's gas. As a general rule such arrangements are primarily for the accommodation of the non-plant owner and certainly not one of the principal purposes of the plant.

In view of the lack of any definite lines of demarcation in this area, it is advisable to handle outside gas on a purchase arrangement if at all possible, thus eliminating the question of performing services for non-members.

ADJUSTMENT OF PRIOR COSTS

Where properties are unitized in order to effectuate a secondary recovery operation, the parties oftentimes desire to adjust their prior investment costs. What costs are to be adjusted and the manner of adjustment vary in different projects. **How the adjustment is handled can have a definite bearing on the income tax position of the various parties, and care should be exercised to assure the resulting tax consequences desired.**

At the outset, it is believed that the normal unitization of properties is an exchange as between the operators for income tax purposes, and as such, can result in a realized gain or loss for income tax purposes although it may not be taxed because of some non-recognition provisions of the Code.

In this regard Section 1031 of the 1954 Code provides that "no gain or loss shall be recognized if property held for productive use in trade or business—is exchanged solely for property of a like kind to be held either for productive use in trade or business —." If there is any property received which is not of a like kind including money, "then the gain, if any, to the recipient shall be recognized but in amount not in excess of the sum of such money and the fair market value of such other property";[10] however, no loss shall be recognized.[11] In the usual unitization, the property given up and the property received are of like kind, and as long as no cash changes hands, no tax will be due by any of the parties to the unitization on account of any exchange. On the other hand where cash adjustments are made the gain to the recipient will be recognized to the extent that it does not exceed the amount of the cash received.

Exchange Provisions

Mention should be made of the effect, if any, of the partnership provisions of the new Code, since the unit operating agreement is considered as constituting a partnership for income tax purposes. Generally speaking, the statute provides that gain or loss is not recognized to the partnership nor to the partners by virtue of the contribution of property to the partnership by the partners.[12] Also, any property distributed by a partnership to a partner

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Correct Counterbalance Means:

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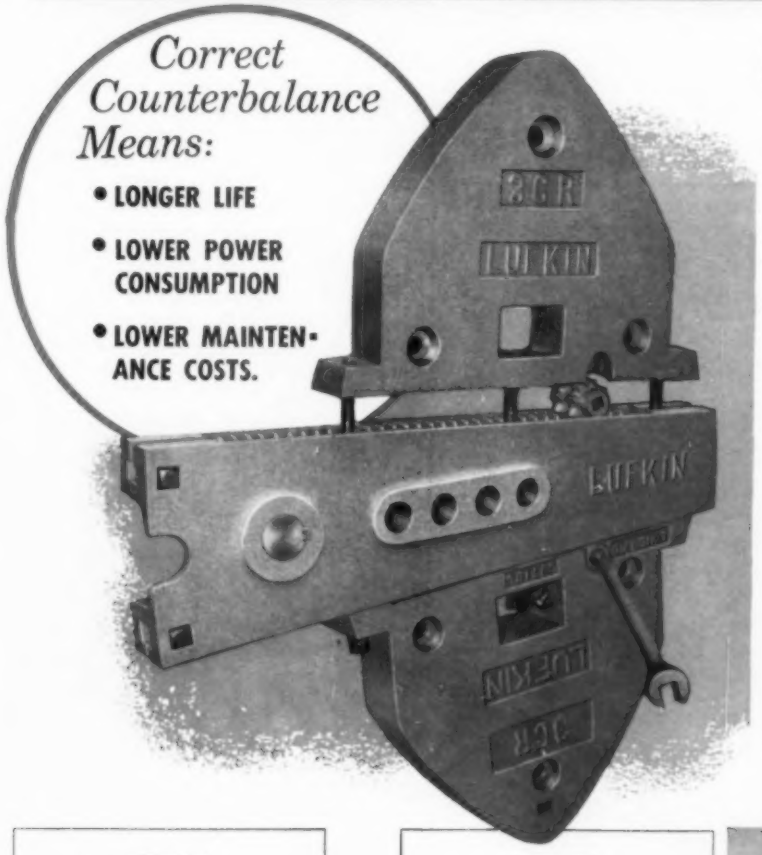
- **LOWER MAINTENANCE COSTS.**



Makes Counterbalance Adjustment Simple and Easy

1. Move cranks to horizontal position and set brake.
2. Loosen nuts holding counterweight using wrench as furnished and sledge hammer.
3. Loosen set screw with ordinary crescent wrench.
4. Insert square on wrench handle into socket in end of pinion and rotate, moving counterweight to desired position.
5. Tighten nuts on counterweight bolts, using wrench and sledge.
6. Tighten set screw.

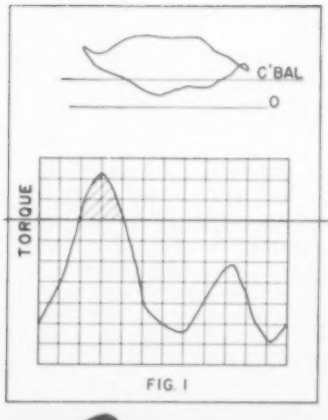


FIG. 1

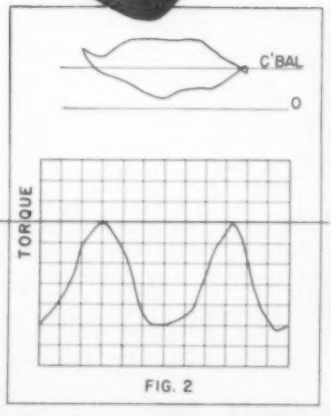


FIG. 2

FIGURE 1. Illustrates the results of incorrect counterbalance. Note peak torque on up stroke exceeds rating of gears.

FIGURE 2. Torque curve on same well shows how proper counterbalance evens out the peaks and reduces peak torque to within gear rating.

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will not result in a gain except to the extent that the money distributed exceeds the adjusted basis of such partner's interest in the partnership.[13] If these provisions are applicable a different amount of taxable gain may well result than where Section 1031 (relating to like kind exchanges) is applicable. However, the regulations under the partnership statutes provide that "if there is a contribution of property to a partnership and within a short period: (1) Before or after such contribution other property is distributed to the contributing partner — such distribution may not fall within the scope of Section 731. Section 731 does not apply to a distribution of property, if, in fact, the distribution was made in order to effect an exchange of property between two or more of the partners or between the partnership and a partner. Such a transaction shall be treated as an exchange of property."[14]

It would seem that in view of this regulatory provision the unitization of properties would be an exchange and not a contribution of property to a partnership and a subsequent distribution by the partnership. Thus, the exchange provisions of the Code would be applicable which means that Section 1031 would be applicable irrespective of whether the unit operating agreement creates a partnership for income tax purposes. Moreover, if an election to be excluded from the partnership provisions is made for the first year, then there appears to be no question but what Section 1031 is applicable.

Equipment

Where the leaseholds as well as the equipment are unitized, as is usually the case, the parties will want to assure that maximum depreciable bases are maintained after the unitization in order that maximum depreciation deductions can be claimed each year thereafter.

The general rule is that where assets are acquired for a lump sum price, the basis of the assets in the hands of the acquiring party is determined by allocating such lump sum to the respective assets on the basis of their relative fair market value.[15]

Where leases and equipment are exchanged in a like kind exchange, the adjusted basis of the transferor in the property exchanged shall be his basis in the property acquired plus any gain recognized, and this will be allocated between the leaseholds and equipment on the basis of their relative fair market values. The result often will be to reduce or even to eliminate the depreciable basis in the equipment acquired since generally the fair market value of the interest in the leaseholds acquired will be substantially greater than the fair market value of the interest in the equipment acquired, and the adjusted basis of the taxpayer in the equipment given up will many times be larger than his adjusted basis in the leaseholds given up. Consequently, depreciation deductions will be lost and no additional depletion deductions will be gained as a rule, since percentage depletion generally will be claimed in lieu of cost depletion.

In order to avoid losing depreciable bases to depletable bases, the unitization of the leaseholds should be separated from the exchange of the equipment.

Thus, leasehold interests should be exchanged for leasehold interests and equipment should be exchanged for equipment. Any cash adjustments should be tied to the exchange to which they relate. While the two exchanges can be contained in the unit operating agreement, they nevertheless should be spelled out separately.

Cash Adjustments

Where cash adjustments are made, the recognized gain will be treated as gain from the sale of assets used in trade or business,[16] which in effect is a capital gain, and any net money paid will be added to the basis of the equipment or leasehold interests acquired.

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Sometimes the parties desire to adjust prior investments by some method other than cash. One such method is the reservation of a production payment by each operator in the amount of his prior investment costs and thereafter all the operators pooled or unitized their respective production payments. The principal advantage of such a method is that no cash outlay is required to adjust investments. Since the production payments are reserved there is no income tax due by virtue of the reservation and the pooling of the production payments so reserved amounts to an exchange of properties of like kind so that the transaction is completely non-taxable.

Production Payments

However, the additional amounts received from the production payments as they are paid out of production is ordinary income subject to depletion, whereas the recognized gain where cash adjustments are used will result in capital gains treatment. Moreover, a party's interest in the production payment will be considered a "separate property" for depletion purposes.[17] This conceivably could have an effect upon the amount of depletion allowable on the production from the working interest inasmuch as the net income from the working interest will be less. Consequently, the 50 percent of net income limitation could reduce the depletion deduction as to the working interest in certain circumstances.

Where reserved production payments are used to adjust prior equipment investments, it should be noted that the basis of a party in his interest in depreciable unit equipment will oftentimes be lower than where cash adjustments are used. This, of course, will make subsequent depreciation deductions lower. However, this factor must be weighed in light of the tax that may be payable where cash adjustments are used as well as the necessity for some of the parties to make a cash outlay upon unitization.

Lease Development

Where some leases have been developed more than others the parties may seek to adjust investment inequities by requiring the owner of the under-developed lease to develop such lease at his own expense. In this regard the party so developing his lease will want to deduct 100 percent of the intangible costs incurred in such development. Therefore, it is advisable to have the unitization of such under-developed leases effective only after the development has taken place. If the properties are unitized prior to the required development by a party and such party stands the total expense of such development, he may well have to capitalize a portion of his intangible costs as cost of acquiring an interest in the unit[18] which would be a depletable cost and of little value where percentage depletion is claimed.

EXPENSES OF FORMING A PROJECT

Generally, certain expenses are incurred in putting a secondary recovery project together, such as legal fees, surveying fees, etc. These fees or expenses are deductible for income tax purposes where only cooperative projects are involved and there is no unitization. The Service has contended, however, that such expenses incurred in connection with the unitization or pooling of properties are capital expenditures and must be capitalized as either depletable or depreciable costs or both.

The case of *Campbell v. Fields*,[19] held that such expenses incurred in pooling gas properties were deductible. It is not known whether the Commissioner will continue to litigate this point or concede. At any rate, the writer is of the opinion that such expenses should be deductible, whether incurred in connection with a cooperative project or a project involving unitization.

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Axelson's 4-ft. Hydrax Jr., a completely hydraulic pumping unit for low-production and stripper wells, has a polished rod capacity of 8,000 lbs. Performs slowly for greater volumetric efficiency. Smooth operation and cushioned reversals assure longer sucker rod life, more service from subsurface pumps.

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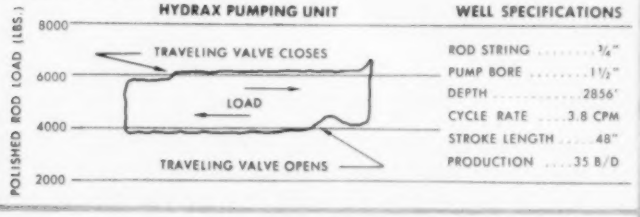

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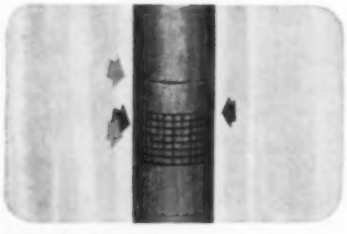
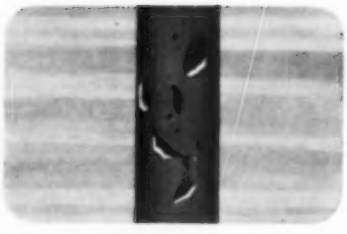
M

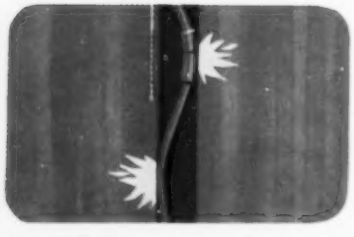
When this happens to your drill pipe... be glad you're using Field Replaceable REED Super Shrink-Grip Tool Joints!



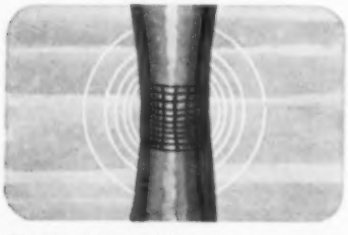
Notch Fatigue (Slip Wear)—Transverse notches, such as those caused by slip teeth can make even relatively new pipe fail. Crosswise notches and scars are natural stress raisers and are an open invitation to failure and fishing jobs.



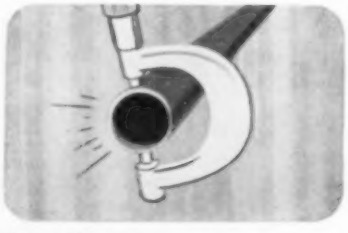
Corrosion Fatigue—Corrosion fatigue is one of the most common causes of drill pipe failure. Pipe becomes pitted. Pits become stress raisers as pipe bends. Cracks develop. Joints deeply pitted are usually unsafe.



Crooked Pipe—Running pipe in compression, dropping pipe while pulling up or laying down joints, or careless handling during transportation can crook pipe. Crooked pipe is more likely to fail from fatigue, and accelerates wear on tool joints.



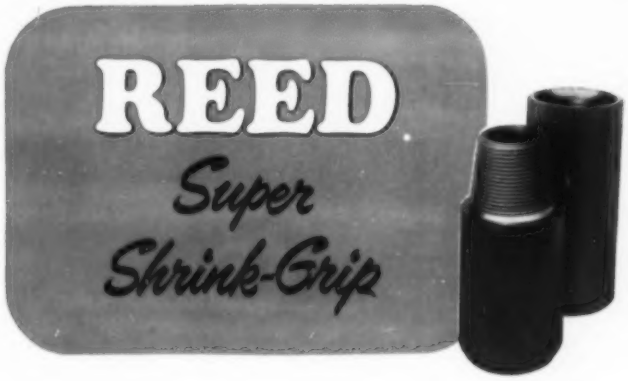
"Necked Down" Pipe—Using tongs on the body of the pipe or careless setting in the slips when tripping heavy strings can crush the pipe. Pulling too hard on stuck pipe will cause it to neck down.



Worn Pipe—The straightest pipe wears. Crooked pipe wears lopsided. Depth of well to be drilled, corrosion and other factors affect how hard pipe is stressed and, consequently, how thin it can be worn before it is dangerous to run.

Most operators have to retire some drill pipe with each well drilled . . .

any cut their loss in half by using



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Drill pipe failures often occur when there are many thousand feet of good service life left in the tool joints. Why lose both? With Field Replaceable Reed Super Shrink-Grip tool joints, you can retire the pipe, remove the tool joints and apply them to new pipe right in the field with your own labor. There's no costly delay, no transportation or shopping expense, and most important . . . you don't lose your original investment in the tool joints which amounts to approximately 50 percent of the cost of your drill pipe-tool joint string.

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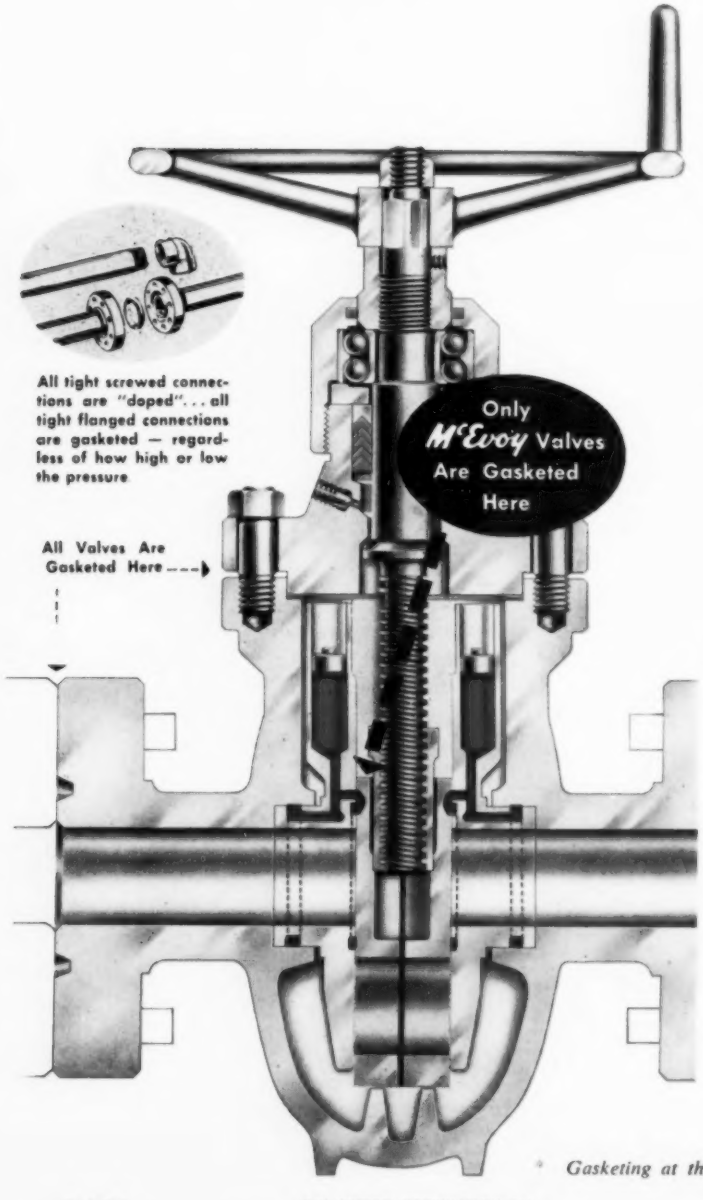
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INTANGIBLE DEDUCTIONS

Certain questions can arise in the development and operation of a secondary recovery project as respects the matter of intangible drilling and development cost deductions. There are two general types of problems in this connection: (1) What intangible costs are deductible generally, and, (2) to what extent may a party claim the deduction.

Intangible costs include the cost of cutting the hole, as well as the labor, and material costs, etc., incurred in placing equipment in the well. In many secondary recovery projects it is necessary to drill input wells and perhaps source wells, such as water wells.

Input Wells, Water Wells

The Service takes the position that input wells are so integrally connected with production that the intangible costs incurred as to such wells come within the option to deduct or capitalize. The *Page Oil Company*[20] case so holds. However, as to intangible costs incurred in drilling and completing a water well, the water of which is to be injected in a waterflood project, the Service takes the position that such costs are not within the option, hence must be capitalized either over the economic life of the source well or the economic life of the property which it serves, which ever is the shorter. There are no decided cases on this point; however, the writer feels that in certain circumstances strong arguments can be made that such costs are within the option.

Even where intangible costs are within the option and a taxpayer has elected to deduct such costs, the taxpayer may nevertheless have to capitalize all or a portion of the costs incurred by him or it.

For instance, where an assignee of an undivided one-half interest in a lease is obligated to the assignor to drill, at assignee's sole cost, a well in consideration for the assignment of such one-half interest, the assignee must capitalize one-half of such cost as leasehold cost, a depletable cost.[21]

Unitized Expense

Where properties are unitized and the drilling of an input well is at unit expense, then it is clear that each party will be entitled to deduct his respective share of the intangible costs, assuming he has elected to deduct intangibles generally.

If the properties are not unitized and an input water well is drilled on a particular lease at the expense of the various interested parties, then the parties who own no interest in the lease on which such well is drilled perhaps will have to capitalize the intangible costs which they pay as an improvement

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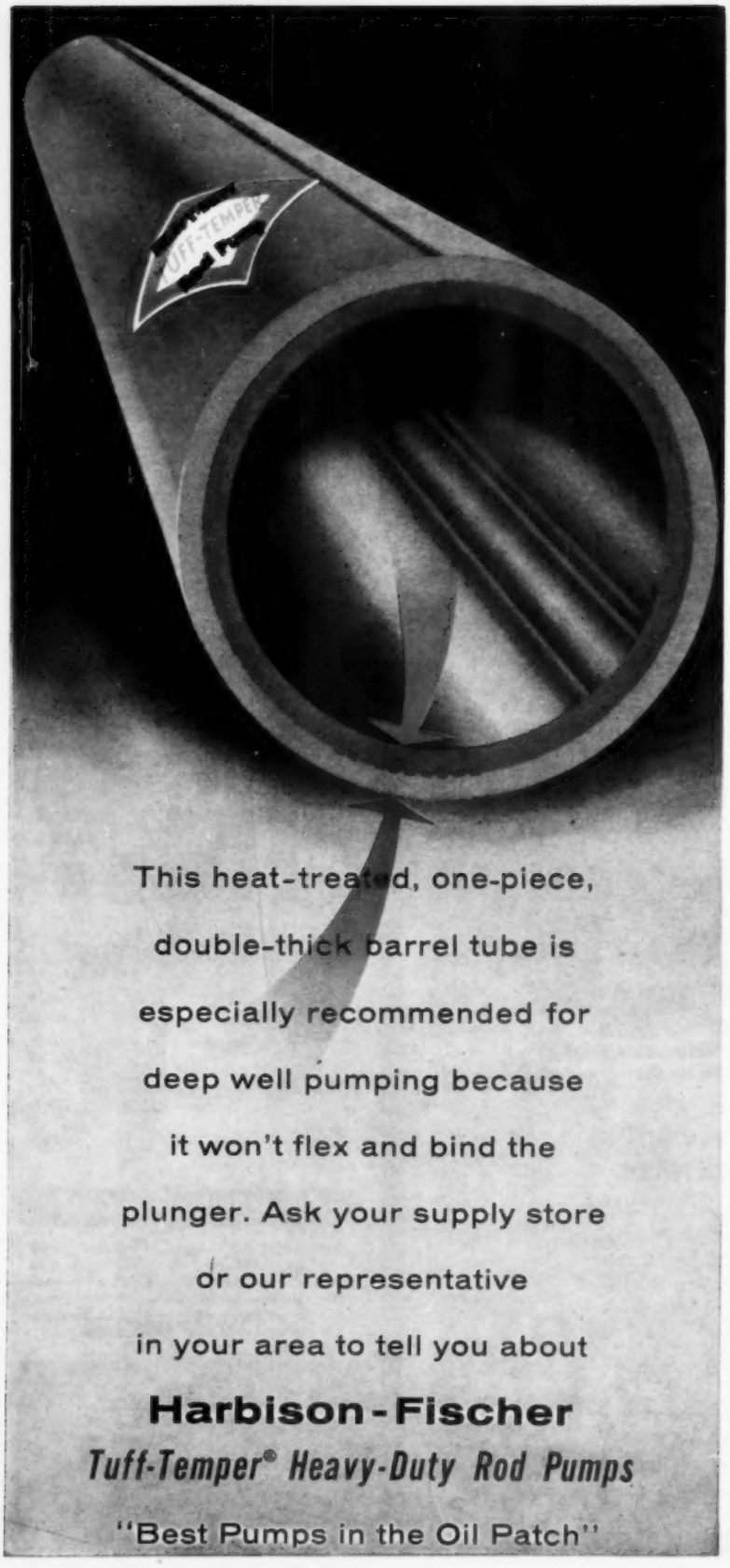
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cost to the leases that they do own which will benefit from the input well operation. The writer feels that these intangible costs should be deductible irrespective of the location of the well since the well will serve and benefit the lease which the payor does own in the project area and this should be sufficient to permit deductibility.

Sometimes in a cooperative waterflood project, input wells are to be drilled on various leases within the project area and in such case it may be equitable to provide that each lease owner will drill at his own expense the input well or wells to be located on his lease. If this can be done equitably then the problem of deductibility of the intangibles can be obviated.

DEPLETION

Depletable Properties

If the project takes the form of a cooperative effort without unitization then, of course, there is no effect, per se, upon the number of depletable properties which an operator has in the project area. If he had two depletable properties before, he will have two depletable properties thereafter.

Where the properties are unitized then it is the writer's opinion that each operator has, as to his working interest, only one depletable property. However, it might be contended that an operator has more than one property in the unit by virtue of the unitization. Normally, this would not have any effect upon the amount of the depletion deduction of the operator as long as production and expenses are allocated on the same ratio, unless one interest contributed is subject to substantial overriding royalties or production payments. In this event the 50 percent of net income limitation might operate to limit the depletion deduction on such interest if considered to be a separate property from his other interest.

In order to avoid the problem of numerous properties in a unit owned by one operator, the operator might consider exercising an election to aggregate all operating interests he may own in the unit.

The aggregation provisions of the 1954 Code[22] require that the election to aggregate a mineral operating interest must be made in the return for the first year in which the owner incurs any exploration, development or operating cost after acquiring the interest. This raises the question of whether an operator "acquired" the interests upon unitization or whether he will be considered to have acquired his interests in the unit at the time he acquired the leases which he contributed to the unit. It is believed that the acquisition of any interest in the unit is as of the time of the unitization.

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Depletable Income

There are certain situations where the determination of what constitutes "gross income from the property" for the purpose of the percentage depletion deduction presents a problem. One such situation is where a cycling operation is carried on, that is, the liquids are taken out of the wet gas and the dry or residue gas is injected into the reservoir. Of course, only the liquids, normally, are sold. The question is whether the entire amount received from the sale of the plant products is depletable income or whether a portion of the proceeds are attributable to a manufacturing process, hence such portion not subject to depletion. The Internal Revenue Service takes the position that a portion of the proceeds are attributable to manufacturing and for purposes of computing percentage depletion the gross proceeds must be allocated between the manufacturing and producing operations. This allocation, according to the Service, is done by reducing the gross proceeds received from the sale of plant products by (1) the operating expenses attributable to the manufacturing function, (2) depreciation on the manufacturing facilities and, (3) a reasonable return on the actual investment in plant facilities, generally 10 percent. This is called the "Fiske" Formula.[23]

Manufacturing or Producing?

Actually, the main determination is what is a manufacturing as distinguished from a producing facility. The main functions involved in the usual cycling operation are separation, absorption, and injection.

Sometimes there is a fractionation process. **Separation is a producing function as is injection, and the Service agrees. As to absorption, opinions differ.**

If there is a fractionation process then the Service will contend perhaps that both the absorption and fractionation are manufacturing processes; however, if no fractionation takes place, then it is possible to get the Service to agree that at least a portion of the absorption function is a producing function. As to fractionation, the Service takes the position that this is a manufacturing function. A strong argument can be made that absorption should be considered a producing function, where a cycling operation is involved, irrespective of whether a fractionation process is carried on, since absorption is an integral part of the cycling operation whereas fractionation is not.

Outside Gas

If outside gas is purchased and injected into a reservoir in a secondary recovery project depletion cannot be

claimed on the subsequent production of such gas. The Internal Revenue Service takes the position that the "salvage value" of the outside gas which is actually injected is to be capitalized as the cost of such injected gas, and, in determining the salvage value, consideration is given to the amount of such injected gas as will not be recovered. When the outside gas is subsequently produced depletion will not be allowed but the capitalized cost per thousand cubic feet will be a deduction when such gas is sold. The additional cost of outside gas which is not capitalized is a deductible item in the year the gas is injected as an expense of operating.

Of course, the injected outside gas commingles with other gas in the reservoir and a question arises as to when the outside gas will be considered produced. In this regard, the Internal Revenue Service will follow the royalty provisions. If the unitization agreement provides that when the cycling operation ceases, 50 percent of the gas thereafter produced will be considered outside gas on which no royalty will be paid, then the Service will also say that only 50 percent of the gas thereafter produced is depletable.

CONCLUSIONS

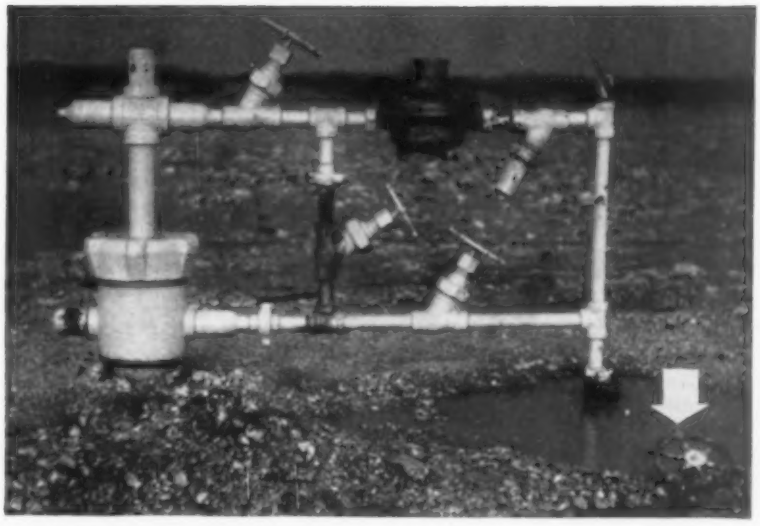
Every project has peculiar aspects from the operational and economic standpoint, as well as the tax and legal standpoint. While some standardization can be developed, in the main each project stands on its own and must be viewed and planned accordingly.

References

1. 1954 I.R.C., Section 7701 (a) (3) provides "The term 'corporation' includes associations, joint stock companies, and insurance companies."
2. I.T. 3930, 1948-2 Cum. Bull. 126 and I.T. 3948, 1949-1 Cum. Bull. 161.
   2a. Ibid.
   2b. Ibid.
3. This is a constitutional requirement as enunciated in Eisner v. Macomber, 252 U. S. 189.
4. 1954 I.R.C., Section 703 (b).
5. I.T. 3930, footnote 2, supra, refers to the usual joint operating agreement as a partnership in a "qualified sense."
6. Bentex Oil Company, 20 T.C. 565 (1953).
7. T.D. 6175, Section 1.761(a) (1).
8. T.D. 6198, Section 1.761 (a) (2) (iv).
9. T.D. 6198, Section 1.761 (a) (2) (iii).
10. 1954 I.R.C., Section 1031 (b).
11. 1954 I.R.C., Section 1031 (e).
12. 1954 I.R.C., Section 721.
13. 1954 I.R.C., Section 731.
14. T.D. 6175, Section 1.731-1 (c) (3).
15. Regulations 118, Section 39.23 (l)-4; E. C. Laster, 43 BTA 159 (1940).
16. 1954 J.R.C., Section 1231.
17. Herndon Drilling Company, 6 T. C. 628 (1946).
18. Regulations 118, 39.23 (m)-16 (1).
19. 229 F. 2d. 197.
20. 41 B.T.A. 952 (1940).
21. Footnote 18 supra.
22. 1954 I.R.C., Section 614 (b).
23. Named for Leland Fiske, Supervising Valuation Engineer, Dallas Region, Internal Revenue Service.

Acknowledgment

This paper was presented under the same title at the Secondary Recovery Symposium, November 1956 in Wichita Falls, Texas, sponsored by the North Texas section of the Society of Petroleum Engineers, AIME. ★ ★ ★



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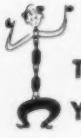

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Society of Petroleum Engineers, AIME Emerges From New Orleans Meeting

John P. Hammond,
Society's 1957 President

New titles have been given the former branches of the 87-year-old American Institute of Mining, Metallurgical and Petroleum Engineers.

Board of Directors of the AIME announced the change at the annual meeting of the Institute in New Orleans, Louisiana, February 24-28.

Society of Petroleum Engineers was formed from the Petroleum Branch. New titles were also given for other branches, Society of Mining Engineers of AIME and Metallurgical Society of AIME.

The petroleum segment, with a membership of almost 11,000, is the fastest growing division comprising 35 percent of the total membership of the parent Institute. In 1946 petroleum engineers accounted for 16 percent. Thirty of the 75 local sections of the AIME are predominately petroleum in membership.

To the oil industry, the development gave new emphasis to the rapidly growing importance of engineering. "This action signalizes a maturity which the petroleum engineering field has fully achieved," said John P. Hammond, Amerada Petroleum Corporation, Tulsa, Oklahoma, new president of the Society of Petroleum Engineers.

Other new officers of the petroleum segment are vice presidents George R. Gray, Baroid Division, National Lead Company, Houston, Texas, and Earl M. Kipp, The California Company, New Orleans, Louisiana.

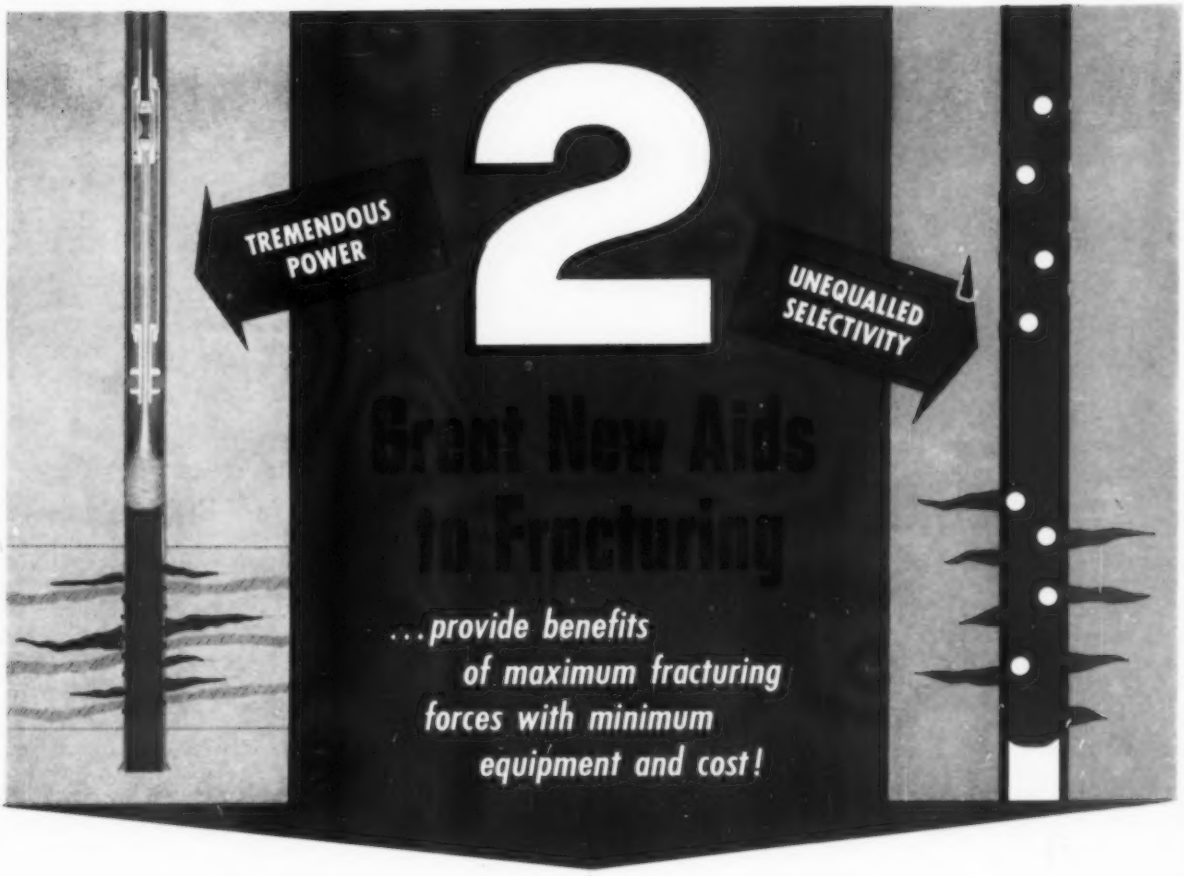
Basil E. Kantzer, Union Oil Company of California, Houston, is president-elect for 1958. T. C. Frick, of the Atlantic Refining Company, heretofore chairman of the Petroleum Branch of AIME becomes past president of the new Society.

The 1957 executive committee of the Society includes Gordon H. Fisher, vice president, Plymouth Oil Company, Sinton, Texas; Henry N. Lyle, general superintendent, Renwar Oil Company,

Basil P. Kantzer,
President-elect for 1958

Corpus Christi, Texas; Wayne E. Glenn, assistant regional manager, Continental Oil Company, Denver, Colorado; Milton E. Loy, Schlumberger Well Surveying Corporation, Tulsa; Jack M. Moore, Dowell Incorporated, Midland, Texas, and M. Buford Penn, Sunray Mid-Continent Petroleum Company, Tulsa.

National officers of the AIME were also named, with Grover J. Holt, of Ishpeming, Michigan, general manager of the Cleveland-Cliffs Iron Company, as president, succeeding Carl E. Reistle, Jr., of Houston, vice president of Humble Oil & Refining Company, who becomes past president of AIME. Dr. Augustus B. Kinnzel of New York, vice president of research, Union Carbide & Carbon Company, becomes president-elect of AIME for 1958.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TODAY, almost everything in the oil industry is coming under the close scrutiny of the scientist. Wide variations in formation perforating results have proved to the oil industry that "fire power" is not the only factor involved in producing consistent results.

Realizing this, a few major oil companies began investigations several years ago which would give indications of the efficiency of a perforating tool under actual down-hole conditions.

The investigations had a two-fold purpose:

(1) To evaluate the quality of the hole made by various perforators under simulated well conditions, including: Diameter and depth of perforation; amount and kind of debris in the perforation and, an important new parameter — the flow which could be anticipated from the perforation.

(2) To evaluate the effect of fluid in the well bore on the perforated hole.

With respect to (1) above, the investigations soon proved that a perforation may be plugged by the slug and other debris formed by the charge itself. This plugging may seriously restrict the flow of fluid through the perforation. It thus becomes evident that simulated flow is a more important measure of the efficiency of a perforator than either size or depth of hole.

A study of (2) above, prompted the oil companies to attempt two remedies: A non-plugging perforating fluid and the permanent well completion method. Again, simulated flow tests were an important consideration in the development of these two new techniques.

By early 1955, the data obtained by the oil companies was so convincing that the management of the Schlumberger Well Surveying Corporation decided to expand the company's perforating facilities to include a flow laboratory. The laboratory was patterned after the one developed by Humble Oil & Refining Company, and adapted certain improvements suggested by Humble engineers.

Laboratory, the first one to be established by a service company, was completed in 1955. It has already had significant impact on the design of several shaped-charge perforators.

Two Steps to Evaluating Flow

To determine the flow characteristics through a perforation, two tests are necessary. First, measure the flow through the ends of a core. The second is to seal one end of the core, perforate that end under well conditions, and measure the flow characteristics through the core under well conditions. The permeability across the whole core is designated K_1, and that, determined through a perforation under simulated well conditions, is called K_2. The ratio

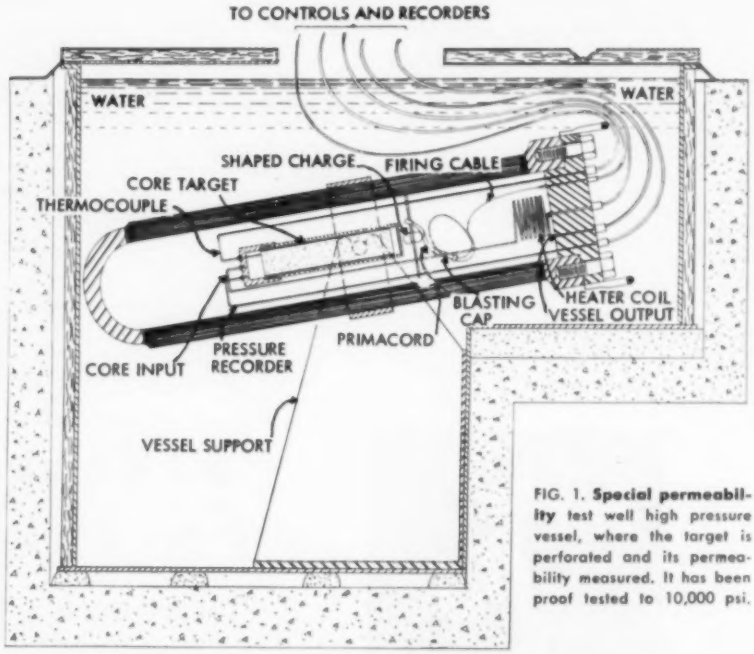
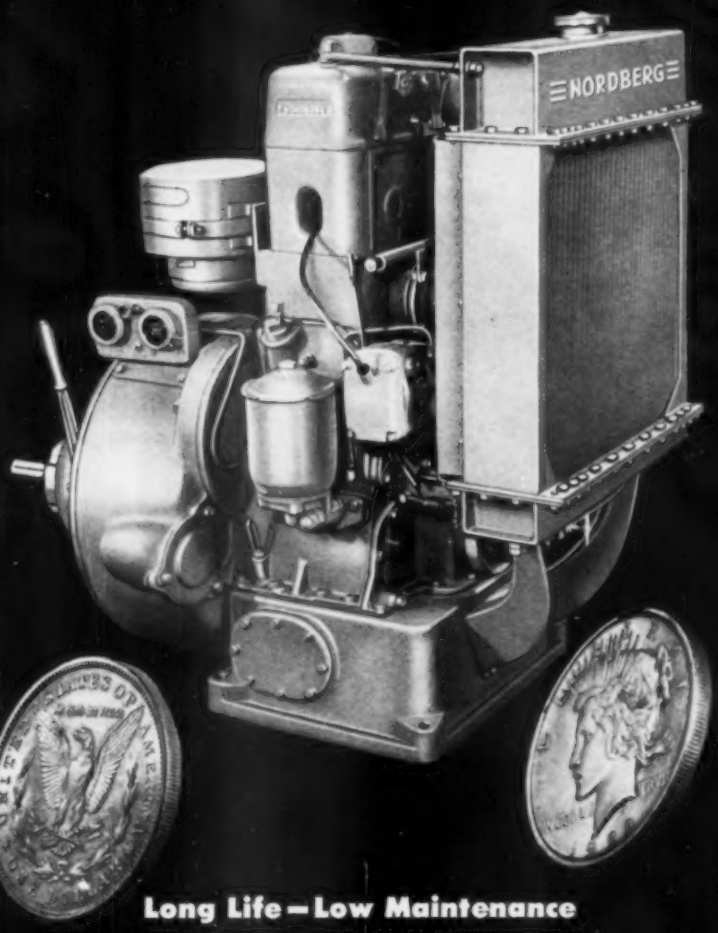


FIG. 1. **Special permeability test well high pressure vessel, where the target is perforated and its permeability measured. It has been proof tested to 10,000 psi.**



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Piston Displ.	83.5 cu. in.	167 cu. in.
Compression Ratio	6 to 1	6 to 1
Speed Range	800 to 1800 rpm	800 to 1800 rpm
Horsepower	18 hp, max.	36 hp, max.

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DONALD C. POWER *Portrait By Fabian Bachrach*

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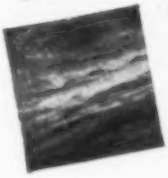

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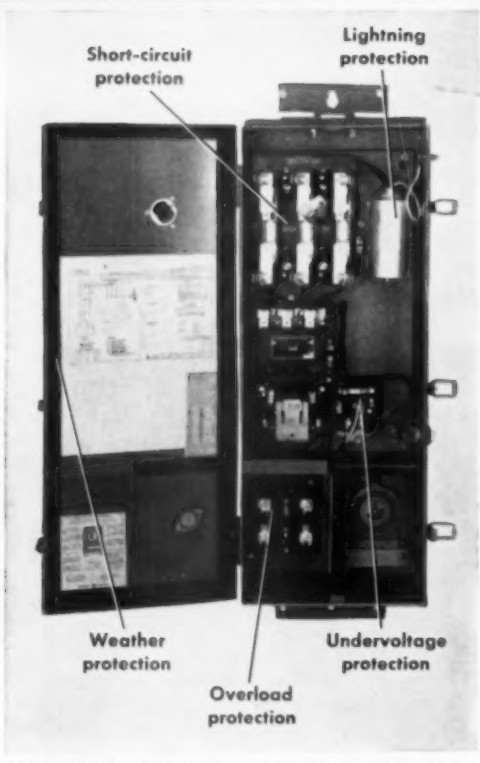

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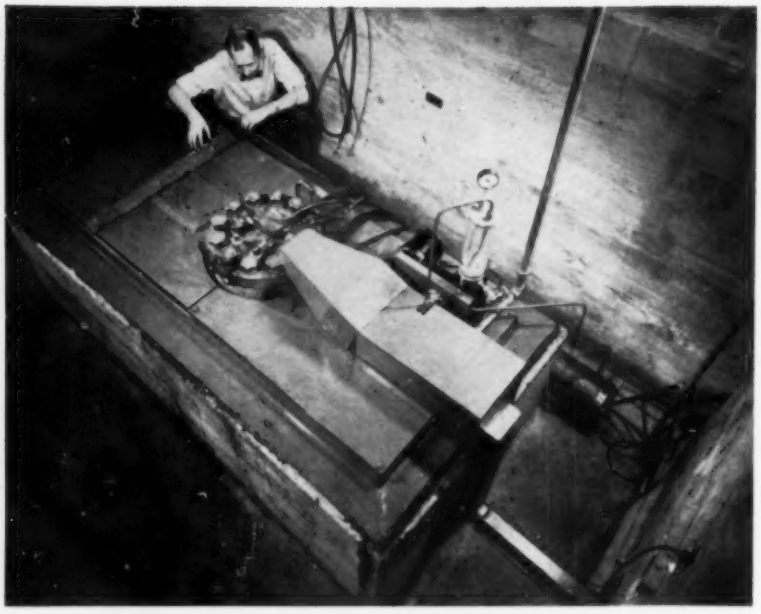


FIG. 2. **View of the test well.** Pressure vessel used in this test cell is a steel cylinder of 12-in. ID, measuring 6 ft overall.

K_2/K_1 is the Flow Index and is a measure of the efficiency of the perforation. If the perforation is plugged by the shaped charge slug or debris, the Flow Index may be considerably less than 1. On the other hand, if a clean perforation is made, the Flow Index may be considerably greater than 1. This is not surprising as the ability of a perforated reservoir to produce more efficiently through perforations than through open-hole has been demonstrated by various investigators.

Determining Flow Index

The following technique has been established for determining the Flow Index. Berea sandstone, cut parallel to the bedding plane, is used for the test core. This is a medium-hard sandstone and the porosity ranges from 15 to 21 percent. The cores are cut 14-in. long and 3 9/16-in. in diameter. The core is thoroughly dried and then processed to simulate oil and water saturations of a producing formation: First, by saturating with 3 percent NaCl Solution and then flooding with kerosine until irreducible water saturation is reached. Thereupon the permeability to oil (kerosine) across the whole core, is determined. This is K_1.

Preparing the Core

Core is next prepared as a target to be tested under well conditions. Core is encased in 4½-in. OD, 16 lb drill pipe, threaded at one end to accommodate the cover through which flowing will be done. Across the opposite end of the core, called the face, is welded a ⅜-in. mild steel plate which will be perforated later. Core is cemented in the drill pipe with cement, there being ¾-in. of cement between the core face and the steel plate.

Determining the Flow K_2

To determine the flow of a perforated core under well conditions requires a special permeability test well. The one being used by the service company is depicted in Fig. 1. Essential feature of this test well is the high pressure vessel in which the target will be perforated and its permeability under controlled pressures measured. This pressure vessel is a steel cylinder of 12-in. ID and 6 ft overall length. It has been proof tested to 10,000 psi. This vessel accommodates the target, harness for holding and firing the shaped charge in front of the steel plate, flow lines leading to the well and input face of the core and pressure recording lines for the well and core face. Surrounding the pressure vessel is a reinforced concrete tank filled with water which can be circulated and heated, thereby maintaining the pressure vessel at the desired temperature. The vessel is tilted

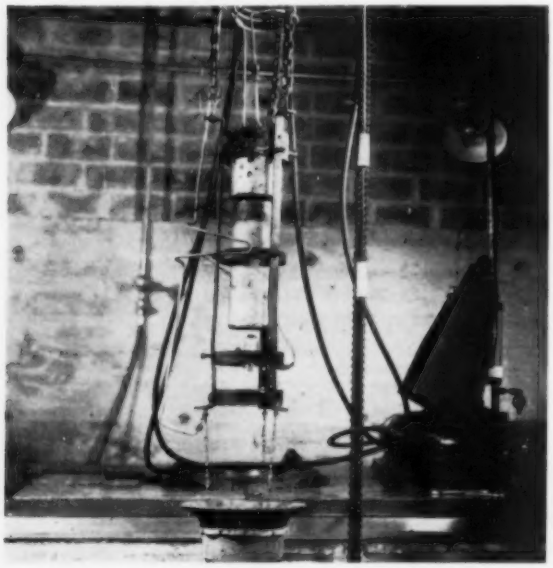


FIG. 3. **Target and shaped charge assembly** prior to lowering into the service company's pressure vessel.

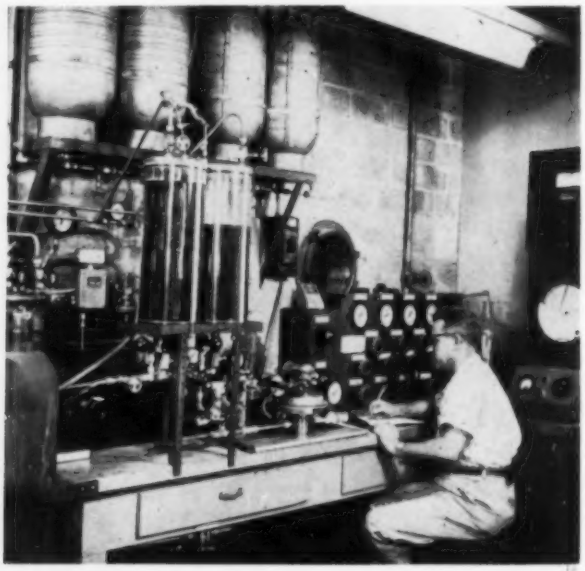


FIG. 4. **Firing, control and measurement panels** for the testing unit.

10 deg below horizontal, the dimensions of the surrounding tank limiting this tilt. Nevertheless, the target is essentially horizontal when perforated and during the flow test through it.

Prior to firing the shaped charge into the target, the temperature inside and outside the pressure vessel is established at 180 F. This requires several hours and is usually done by setting the temperature controls to operate overnight. Then the pressure is set at each end of the core. Simulated well conditions are established depending on the type of perforating gun.

Solid or retrievable type shaped charge perforators are fired with differential pressure into the reservoir. Hence, when these shaped charges are tested, 1500 psi is set at the face of the core, and a 1000 psi at the back, resulting in a 500 psi differential into the target.

Expendable or through-tubing shaped charges are usually fired with differential pressure out of the reservoir into the well as is the practice in permanent type well completions. When this type of shaped charge is tested,

LAUGH WITH BARNEY

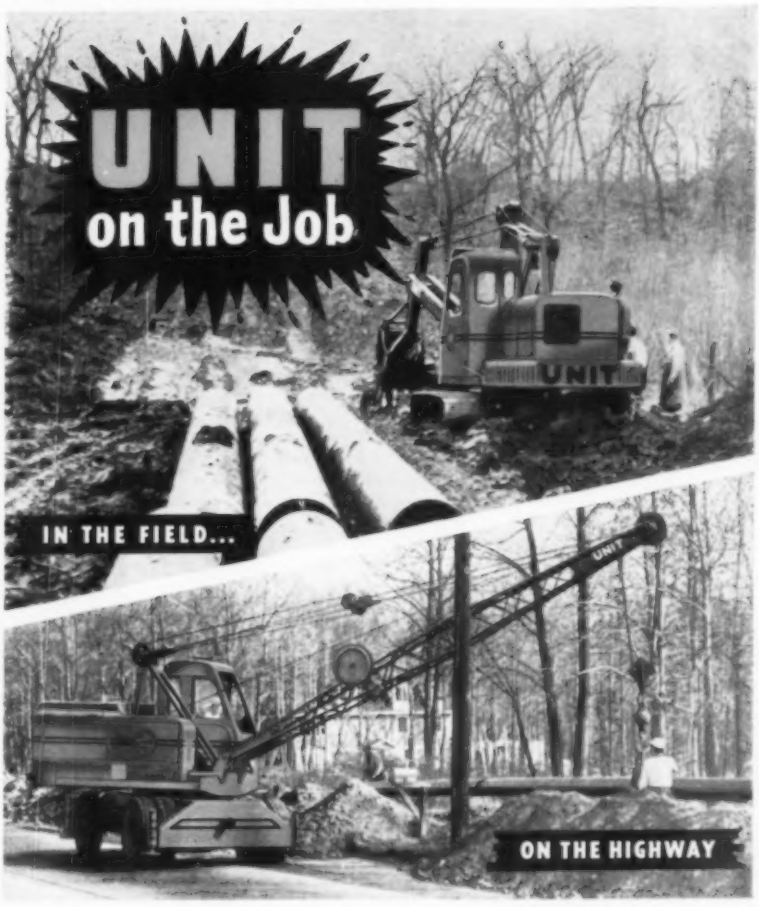
A home owner was mowing his lawn dressed in his oldest clothes. A woman in a fine car stopped and asked him: "What do you get for mowing lawns?"

"The lady who lives here lets me sleep with her," replied the home owner. The lady drove away without a comment.

1000 psi is set at the face and 1200 psi at the back of the core, simulating 200 psi out of the formation into the well.

When pressure differential and temperature are established, depending on the type of shaped charge, the shaped charge is fired. If the charge is a solid carrier type, the pressure differential is immediately reversed to 200 psi out of the core, i.e., 1200 psi at the back and 1000 psi at the face. This simulates well flow after hydrostatic head has been reduced. In the case of expendable shaped charge testing, the 200 psi into the well is maintained, simulating conditions in permanent type well completions.

Filtered kerosine is flowed through the target. Equilibrium of flow rate is usually reached after 10 to 15 liters of kerosine have been flowed but an additional 25 to 30 liters of kerosine is pumped through. Pressure differential of 200 psi into the well is maintained by an accurate, pressure differential regulator. The temperature of 180 F is controlled by the I/C thermocouples regulating the heater coils. Measurement of the flow rate yields the value of K_2 and the Flow Index K_2/K_1 determined.



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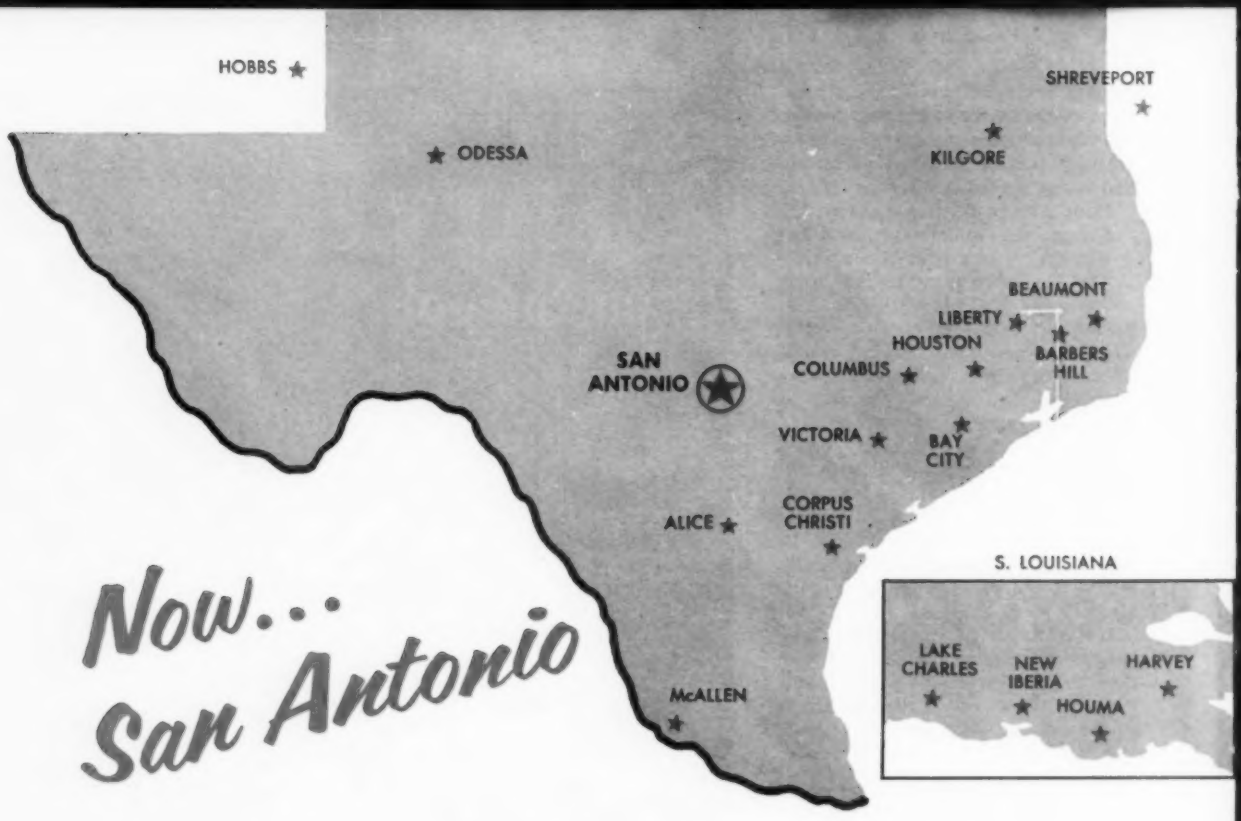

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Interestingly, this tension tubing anchor was run strictly to prevent rod jobs. Yet look what happened to pumping efficiency!

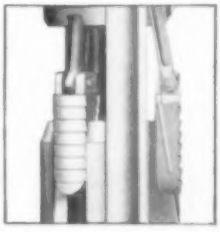
The Double-E Tension Tubing Anchor

HERE'S WHAT IT DOES: Efficiency in a pumping well increases tremendously when the tubing is correctly anchored in tension! Here's how:

1. You get more fluid lifted per stroke
2. Working life of tubing and rods is increased
3. Rod jobs are greatly reduced
4. Collar leaks and wear are eliminated

HOW TO USE IT: Install the tension tubing anchor above or below the pump – or at any desired depth. Set the tool by rotating the tubing a partial turn to the left. Then exert an upward pull on tubing string. The tubing is now anchored in tension.

HERE'S HOW IT WORKS: With its powerful grip on casing, tubing is now held motionless. This eliminates wear between tubing and casing. Also, with strain of load-reversal off the tubing joints, costly collar leaks and damaged threads are prevented. You get much more fluid lifted per stroke and an increase in working life of entire tubing string.



HOW TO RETRIEVE: Simply lower and rotate the tubing a partial turn to right and anchor is re-jayed. If re-jaying is impossible, merely exert a straight-up pull *in excess* of the Slip Failure Rating*. The Double-E Tension Tubing Anchor is designed so the slip-flanges shear upon excess pull. This releases the slips and the tubing string can be easily retrieved without loss of parts in the hole.

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MISSION PLUG VALVES
Texas pressure maintenance plant

At the left, you see two of the three Mission Plug Valves that pointed the way to lower overall maintenance costs to the operators of a West Texas Plant. They proved to a skeptical management that Mission Valves *actually do cost less* because they last longer and require less maintenance.

These three valves were the only Mission Valves installed when the plant was built early in 1950. The two valves shown are installed on a scrubber blowdown near an injection well and the third was in the injection line just before the scrubber.

All three valves handle wet sour gas at 4000 psi. All have been in continuous service since 1950 and all three still work perfectly. They are among a very few of the original valves still operating.

Mission Plug Valves were originally accepted simply because no other valves were available. Their performance has been so outstanding that they are now among the first chosen for service at this plant.

There are many reasons for the long life and dependability of Mission Valves, but the most important is the *Automatic-lubrication system* — exclusive with Mission in plug valves.

Without this system, a small leak could start and serious valve damage could occur before an attendant became aware that the valve was leaking.

But the automatic lubrication system serves as an untiring sentinel — automatically stopping leaks *before* they start — and before valve damage can take place.

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Mission Plug Valves, like other Mission Products, are available through supply stores everywhere.

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Southwest

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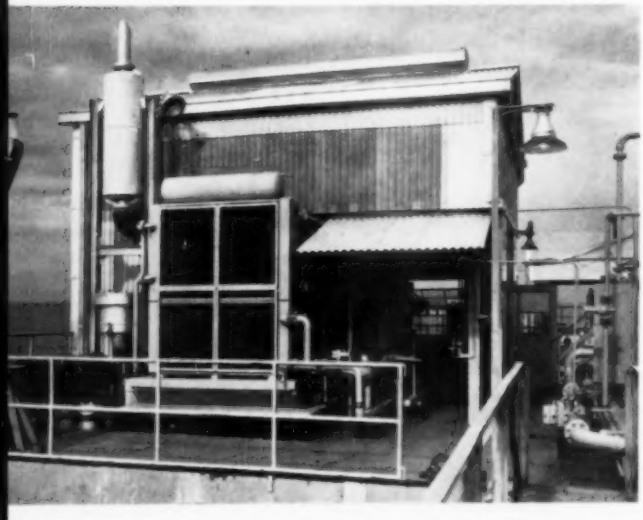

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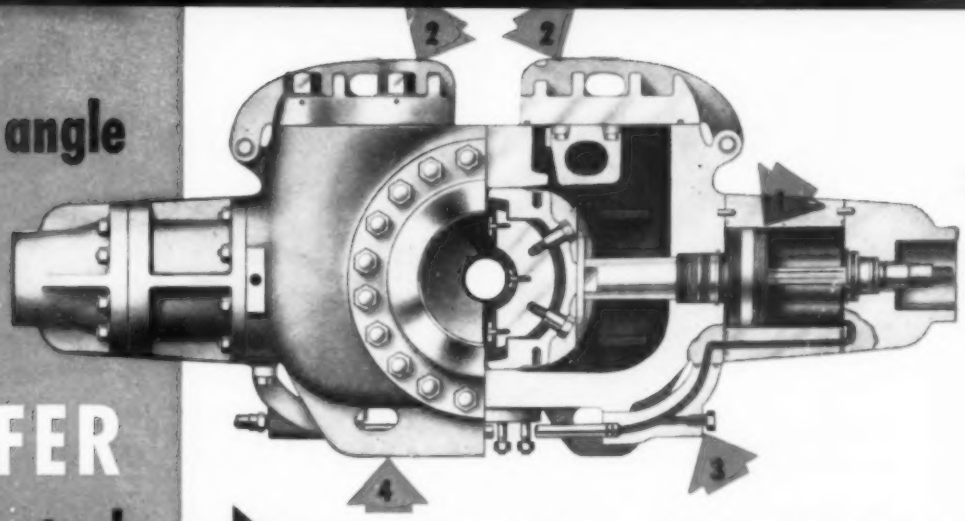
Another angle on SHAFFER Cellar Control Gate Features



TOP VIEW *emphasizes* BASIC DESIGN ADVANTAGES

1 Note the *Single* hydraulic piston by which each ram is actuated. Not only is this piston *directly behind* the ram for maximum operating efficiency, but one-piston-per-ram means:

a. Fewer and simpler operating parts.
b. Fewer hydraulic seals to maintain.
c. Simpler manifolding of hydraulic lines.
d. Easier servicing when necessary.
e. More-favorable ratio of piston area to piston circumferential seal — therefore less internal friction plus increased efficiency.

2 Note how the patented doors through which the rams are serviced open along the *side* of the gate where there is plenty of room.

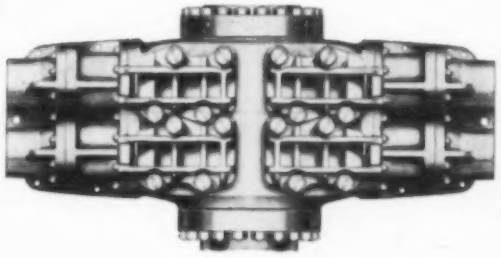
There is no need to expand critical *end* dimensions of the gate for servicing the rams — nor is it necessary to allow extra space above the gate. Since end and height dimensions are the most critical ones in governing cellar requirements, Shaffer's basic advantages here are of paramount importance!

3 Note how all manifold connections are compactly unitized on one side of the gate. Connections are quick and easy to make — equally easy to service.

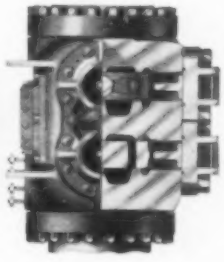
4 Note the sturdy integral ribs upon which the gate "slides" for easy loading, unloading and storage. This feature also protects against damage to studs, lines and other parts.

You have probably seen the Shaffer Hydraulic Cellar Control Gate from the side view many times before. But to get a better idea of the really important advantages found in Shaffer Hydraulic Gates, take a close look at this *top* view...

FRONT VIEW



END VIEW



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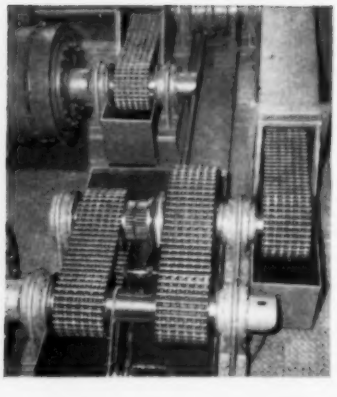

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You Need Nothing More Than PGAC ELECTRICAL LOGS ...They Give All The Answers!

4 RESISTIVITY CURVES and 1 S.P. = 5 Curves for more data

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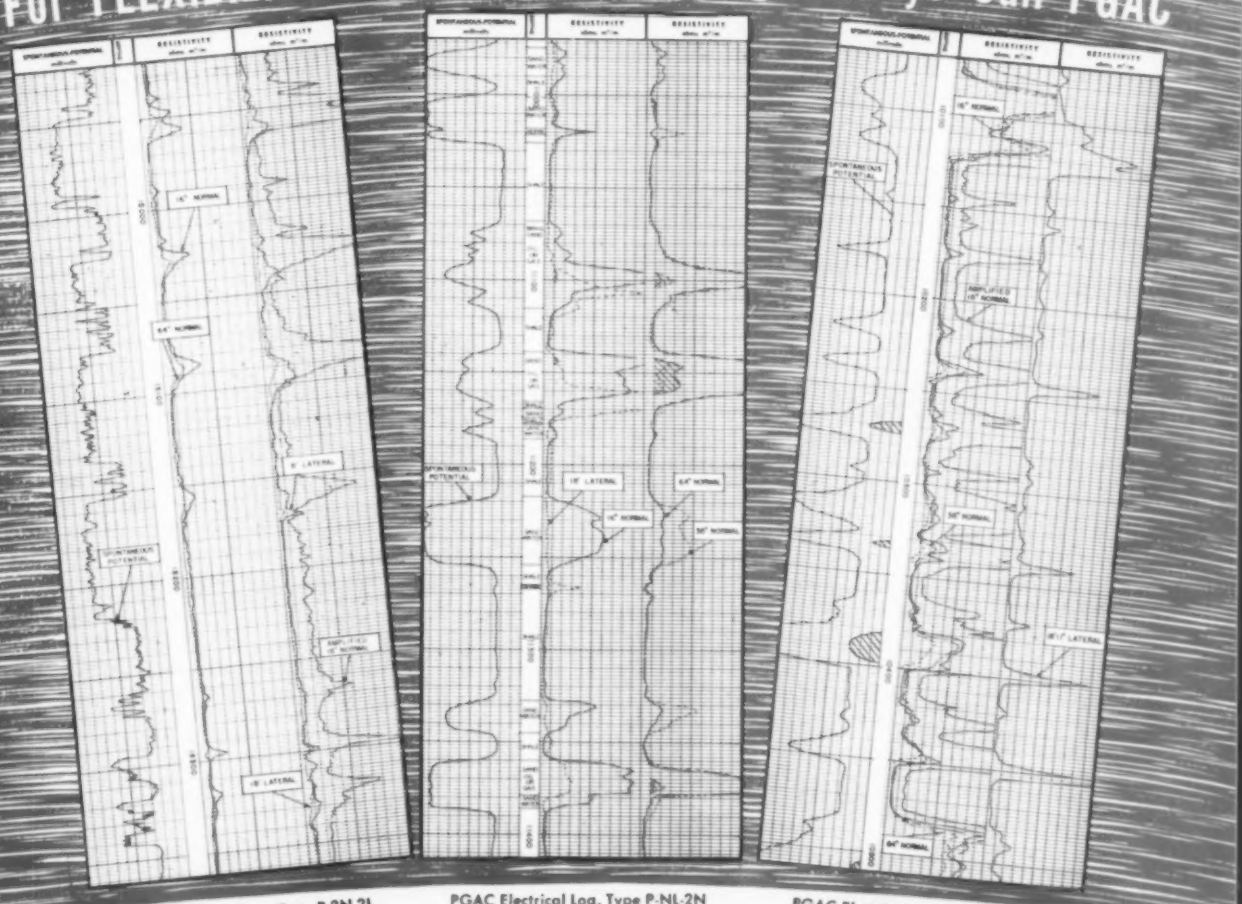

PGAC Electrical Log, Type P-2N-2L
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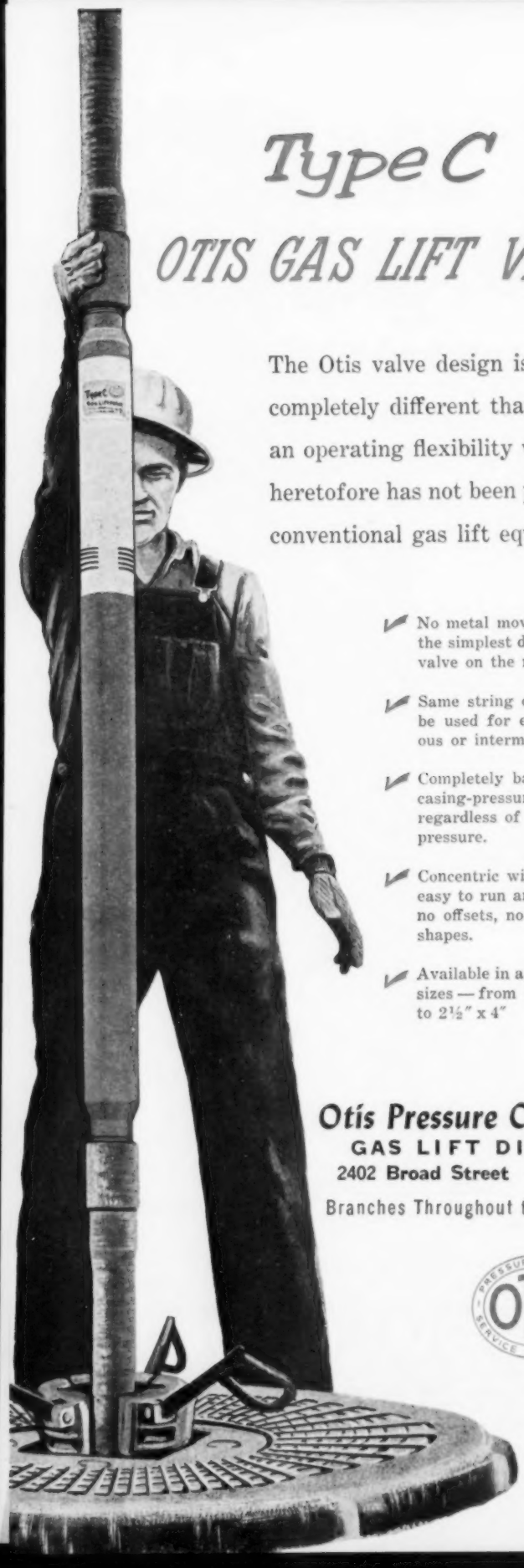

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The Otis valve design is so completely different that it provides an operating flexibility which heretofore has not been possible with conventional gas lift equipment.

- No metal moving parts . . . the simplest design of any valve on the market today.
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PRESSURE CONTROL — OTIS — SERVICE — EQUIPMENT

Results of Flow Lab Studies

One significant result of this flow laboratory is a "no-plug" shaped charge. As the name implies, this charge has little or no plugging action on the perforation and gives a consistently higher flow index than that of previous designs. The no-plug charge produces a very small slug which usually remains in the gun and so does not enter the perforation.

Development of the 2⅛-in. capsule-jet is another example of the influence of flow lab studies. It also proved the unreliability of confining flow lab testing to surface targets. In developing this charge, two different designs were evolved. Testing of these designs in surface targets revealed that one design was consistently superior to the other, with respect to depth of penetration and hole size. When tested in the flow laboratory, however, the design which appeared to be inferior in surface targets, consistently yielded a higher flow index. This design, of course, was adopted for production.

LAUGH WITH BARNEY

A young couple met and married in a Florida resort. They agreed to begin life anew and not discuss their past.

One day they were sitting around the pool — he walked over to the pool and made a series of excellent dives from the high diving board. He returned to his chair and sat down.

"Honey!" his wife exclaimed, "that was wonderful. Where did you learn to dive like that?"

"Mary, we agreed not to discuss our pasts, but I'll tell you about my diving. I was high-diving champion for three years."

Shortly afterward Mary decided to take a dip. She slipped into the pool, and swam the length in record time. When she returned to her chair John exclaimed, "Mary, you, too, must be a swimming champion!"

"Well, honey, since you asked—I was a call girl in Venice."

Improved Lab Being Built

In Schlumberger's new engineering building now under construction, a larger and improved flow laboratory is being built. Both bullets and shaped charges will be tested. From results already achieved, it is felt that many more important improvements in perforating can be expected from these new testing facilities.

References

Allen, T. O., and Atterbury, Jr., J. H., "Effectiveness of Gun Perforating," AIME T.P. No. 3740.

Allen, T. O., and Worzel, H. C., "Productivity Method of Evaluating Gun Perforating," API Paper No. 906-1-H.

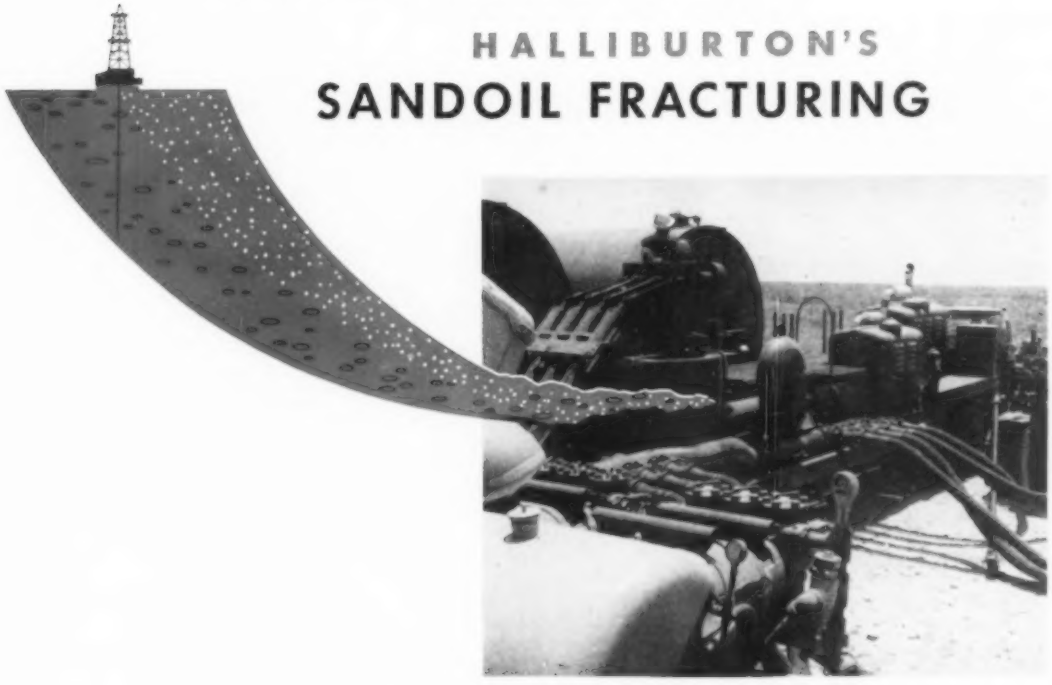
Krueger, R. F., "Joint Bullet and Jet Perforation Tests," API Paper No. 801-32J.

Morgan, B. E., and Priest, G. G., "A Non-Plugging Perforating Fluid," AIME, Paper No. 682-G.

★ ★ ★

economical for small jobs, too

HALLIBURTON'S SANDOIL FRACTURING



The fact that SANDOIL fracturing is economical for big volume jobs means that comparable economy is also possible where smaller volumes of fluid and propping agent are required. Inexpensive, readily obtainable crude or refinery cuts and blends are used for the fracturing and carrying fluid. Emulsion problems are minimized by chemicals that can precede, follow or be mixed with the fracturing oil.

You need pay no premium for big units on small volume jobs. Halliburton's specially designed pumping and continuous proportioning equipment is sized to the job. That's another reason why you save with Sandoil fracturing.

Continuous proportioning at well site permits rigid control of sand ratios and fast, high horsepower pumps provide optimum controlled injection rates at desired pressures.

For big or small volume fracturing, Halliburton's Sandoil process can save you money... and increase production profitably. It will pay you to discuss it with your Halliburton representative. Call the local or district office or write the Halliburton Oil Well Cementing Company, Duncan, Oklahoma.

Ask for bulletin "Elements of Hydraulic Fracturing"

HALLIBURTON

OIL WELL CEMENTING COMPANY

PIONEERS IN FRACTURING SERVICES

JUST MINUTES AWAY FROM ANY RIG

EXPLORATION ACTIVITIES

OKLAHOMA

★ A Hart sand discovery has been made by Phillips Petroleum Company at its No. 1 Jones, 4½ miles east of the Knox field in Stephens County. Well has been acidized and fracture-treated. Productive zone is at 9241-60 ft. It swabbed 70 bbl of oil in nine hours with a small show of water, then made 72 bbl of oil in the next 11 hours. Test was carried to a total depth of 9440 ft, with 5½-in. casing set at 9400 ft. Well was drilled by Falcon-Seaboard Drilling Company.

★ An 18,000 ft objective depth has been set for the No. 1 Sterba-Ordovician, Magnolia Petroleum Company's geological wildcat in the Cement field, Caddo County. Well cored at 14,334-53 ft in the Springer sand, revealing some oil stain and odor. Crews are conditioning hole prior to drilling ahead at 14,539 ft. Big Chief Drilling Company holds the drilling contract.

★ Offset acreage to British American's deepest Oklahoma pool in Grady County has brought a bonus of $59,701 at a Muskogee office Indian lease sale in March. Byron A. William, Ardmore, paid the record price for a 70 acre tract, offsetting B-A's No. 1 Teter, which in turn offsets B-A's No. 1 Reed, now the state's deepest producer.

★ British American Oil Producing Company has staked its seventh deep test in Grady County, and has made application for 160-acre spacing. New well is the No. 1 Baker, slated to go to a depth of 15,800 ft.

MISSISSIPPI

★ Gulf Oil Corporation's No. 1 Welch Unit, a wildcat in Jones County, has found a high-gravity oil pool at a depth of 11,280-86 ft. Well was drilled to 12,642 ft. On test, well flowed 9.07 bbl per hour for a calculated potential of 217 bbl of oil a day. Crude tested 43 deg gravity. Discovery is near the village of Gitano, and new pool has been designated by that name, according to the Mississippi Nomenclature Committee.

★ Several new wildcats are being watched in various parts of the state. All were staked and spudded in mid-March. Deckard Drilling Company and Womack and Wilson have staked No. 1 Lightsey as a 5600 ft test in Jasper County, 1¾ mile north of the Heidelberg field. Same operators have also filed to drill the No. 1 Wallace, a 5600 ft wildcat in Scott County, 10 miles north of Morton. John S. Callon No. 1 Board of Supervisors is a new 7500 ft wildcat 2 miles northwest of Derrington, in Scott County. In Adams County, H. L. Rowley, Inc. is trying for new oil 2 miles southwest of the LaGrange pool at the No. 1 Goude. This test will go to 6700 ft.

WYOMING

★ Discovery on the Diamond Ranch unit in Carbon County has been made by the Ohio Oil Company, pumping 384 bbl of oil from the Lakota formation daily on completion test. Well is the company's No. 1 Unit, completed with perforations at 5377-5426 ft. Confirmation well is nearing completion, the No. 2 Unit, with casing set at 5537 ft. No. 3 Unit well has been spudded.

★ Gas discovery has been assured by Ohio Oil in the Cambrian zone of the Oregon Basin field in its No. 22 Samuel, in Park County. On drillstem test at 5747-70 ft, well gaged 3,271,000 ft of gas per day. Drilling is continuing to granite. Oregon Basin field produces from the Phosphoria, Tensleep, and Madison formations.

COLORADO

★ Four Corners field area is drawing a new test to the granite by The California Company. The No. 1 Ute Tribal, a wildcat that stopped temporarily in the Lower Pennsylvanian at 7270 ft is being cored ahead. Paradox, the original objective, was called at 6411 ft, and crews have been coring intermittently since 5500 ft.

ALABAMA

★ New wildcat has been spudded in south-central Lawrence County, about 40 miles south of the Alabama-Tennessee state line. Test is to be drilled by Frank Burt and S. L. Bass, and is the No. 1 Shirley Smith. It is slated to go to the Knox dolomite.

★ In the Bay Minette area of Baldwin County, in the extreme southern part of the state, Sun Oil Company has begun the No. 1 International Paper Company. Contract depth is 7700 ft.

NORTH DAKOTA

★ Lodgepole and Mission Canyon formations will be tested in a rank wildcat scheduled in Dickey County, southern part of the state, by Calvert Drilling, Inc. and associates. This test well, the No. 1 Kamm, will be the last of 10 that Atlantic Refining and Mobil Producing companies have farmed out to Calvert. Other nine wells were in Logan County and all non-productive.

CANADA

★ Second Slave Point zone oil discovery has been reported by Home Oil Company, Ltd. in the Swan Hills area of Alberta. Latest discovery is 25 miles northeast of the group's successful Virginia Hills well that also found oil in the Slave Point, a Middle Devonian formation. Both wells are north of the Pembina field (Virginia Hills is 75 miles north and Swan Hills is 100 miles north.) Home Oil's Regent Swan Hills No. 8-11 well topped the Slave Point at 7850 ft. Test of section between 7795 and 7923 ft flowed gas in 25 minutes and recovered 2500 ft of clean 40 deg oil. This discovery is on a 92,160 acre farmout from Regent Refining (Canada) Ltd.

★ Lion Oil Company, division of Monsanto Chemical Company's first oil find in Canada has extended limits of the North Nottingham field. New production is from the Nottingham No. 6-32, completed in the Mission Canyon (Mississippian) formation through perforations from 3654 to 3664 ft. On initial test, well flowed at the rate of 144 bbl of oil per day through a 16/64-in. choke. It has been granted a production allowable of 183 bbl of oil per day. Located in Land Sub-division Six, Section 32-5-32 WPM, the well is about 50 miles northwest of the North Souris field which Lion discovered in 1955 in Bottineau County, North Dakota.

CALIFORNIA

★ Deep drilling campaign has been slated by the Texas Company in the old Buttonwillow gas field of Kern County, in the San Joaquin Valley area of the central part of the state. The Texas Company has reportedly taken a 1300 acre lease in the area from the Southern Pacific Company.

TEXAS

★ The A. S. Genecov, Trustee & M. B. Rudman well No. 4-B Fee in the J. M. Oden Survey, South Hallsville Field, Panola County, Texas, potentialed for an open flow of 54,000,000 cu ft of gas in 24 hours with 29 bbl of condensate per million cu ft. Production from this step-out well is from the Crane zone of the Pettit formation through perforations from 6491-6501 ft. The Dallas operators are now drilling their well No. 5-B at 5500 ft which is a further step-out to the southeast.

every 21 MINUTES of every working day . . .

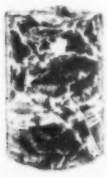
Core Lab starts a NEW JOB

At the end of 1953, Core Lab was beginning a new job every *forty-one minutes* of every working day. Today, the record reads — "every 21 minutes." What happens in a petroleum service company when its volume of service virtually doubles in three short years?

In Core Lab's case, this rapid growth has created an opportunity to broaden the benefits of commercial reservoir engineering. It has given us elbow room to challenge the increasing number of perplexing problems facing an operator in his search for new oil and its optimum recovery.

Specifically, Core Lab has re-invested this sound growth in — *comprehensive technical training for carefully selected field and lab personnel; the development of the industry's finest commercial Special Core Analysis Studies Group; the opening of twelve new permanent field laboratories; the use of electronic calculation equipment which, in combination with reservoir data from 62,000 wells, is unveiling facts of historic significance; the organization of a complete Reservoir Engineering and Consulting staff; the building of a fleet of modern, skid-type well logging units; the installation of a sand-packed column to predetermine results of various injection-and-recovery processes; the maintenance of a broad Research and Development program to handle specific area problems, etc. The list goes on and on.*

When we deliver *your job*, it has inherited the benefits of Core Lab's progress.



Have you seen Core Lab's three new folders — "Average Productive Characteristics of Oil and Gas Formations in Texas RR Comm. District IV"? Send request on your company letterhead to address below. Please mention this publication.

CORE LABORATORIES, INC.

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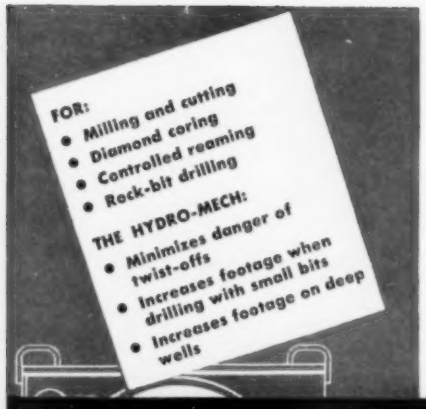
FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD B-153

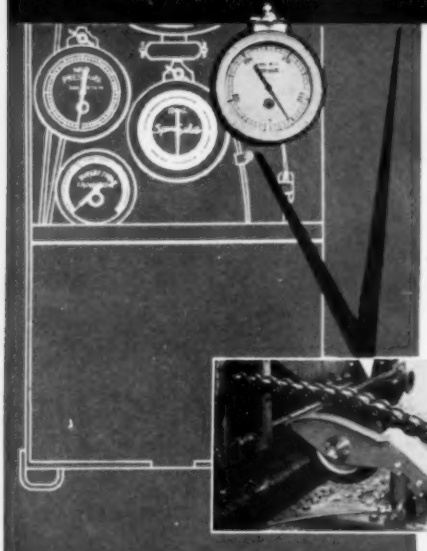


Easily installed on any chain-driven rotary.

Responds to the slightest torque changes.

Adjustable for net-torque-on-bottom.

WHY MANY OPERATORS DEMAND HYDRO-MECHS ON ALL THEIR RIGS



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Models for single or double-link chains.

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Torque is one of the most important variables in any drilling operation — with too little, you're wasting men and equipment; with too much, you're courting an expensive twist-off. Recognizing these pitfalls, more and more contractors and operators are demanding that their rigs be equipped with Hydro-Mech torque gauges. Compared to a $10,000 fishing job, the cost of a Hydro-Mech is certainly negligible.

Distributed through Reed, National, and other recognized supply houses.

MARTIN-DECKER CORP.
HOME OF THE WEIGHT INDICATOR — LONG BEACH, CALIFORNIA

JAMAICA

★ Pan American Petroleum Corporation has abandoned a 8732 ft wildcat, and with it, its search for oil at Santa Cruz. Pan American's oil search in this area began 17 months ago—unsuccessful to date.

INDIANA

★ John Buchman, Wausau Petroleum Company and C. E. O'Neal have confirmed the South Princeton pool of Gibson County. The same group of operators opened this southwest ern Indiana pool earlier this year. Group's No. 2 Jessie Reed, 4 miles from Princeton, swabbed 40 bbl of oil and hour through perforations in the Benoist at 2235-44 ft.

CUBA

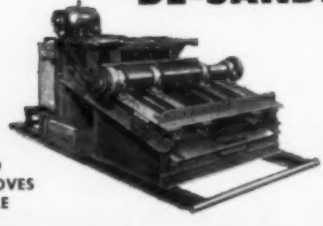
★ Pan American Petroleum Corporation has decided that its Cuban affiliate's next well would probably be located offshore, off the southern coast of the island. Company has already drilled two onshore dry holes. No dates have been set for spudding, pending arrangements for equipment and installation.

NEW MEXICO

★ Tennessee Gas Transmission Company has confirmed a new Permo-Penn sand pool in central Lea County. Company's No. 1 State-Kemnitz B well tested on drillstem test at the rate of 2000 bbl per day. Test was through a ⅝-in. choke from a depth of 10,682-713 ft. Drilling is continuing to a projected depth of 11,500 ft, with additional test to be taken at 50-ft intervals to confirm oil sand thickness. This well is a mile west of the company's discovery, completed in November, with a sand thickness of 123 ft.

ALWAYS IN OPERATION WHEN PUMPS ARE RUNNING

NEW MODEL RUMBA DE-SANDER



ALSO REMOVES SHALE

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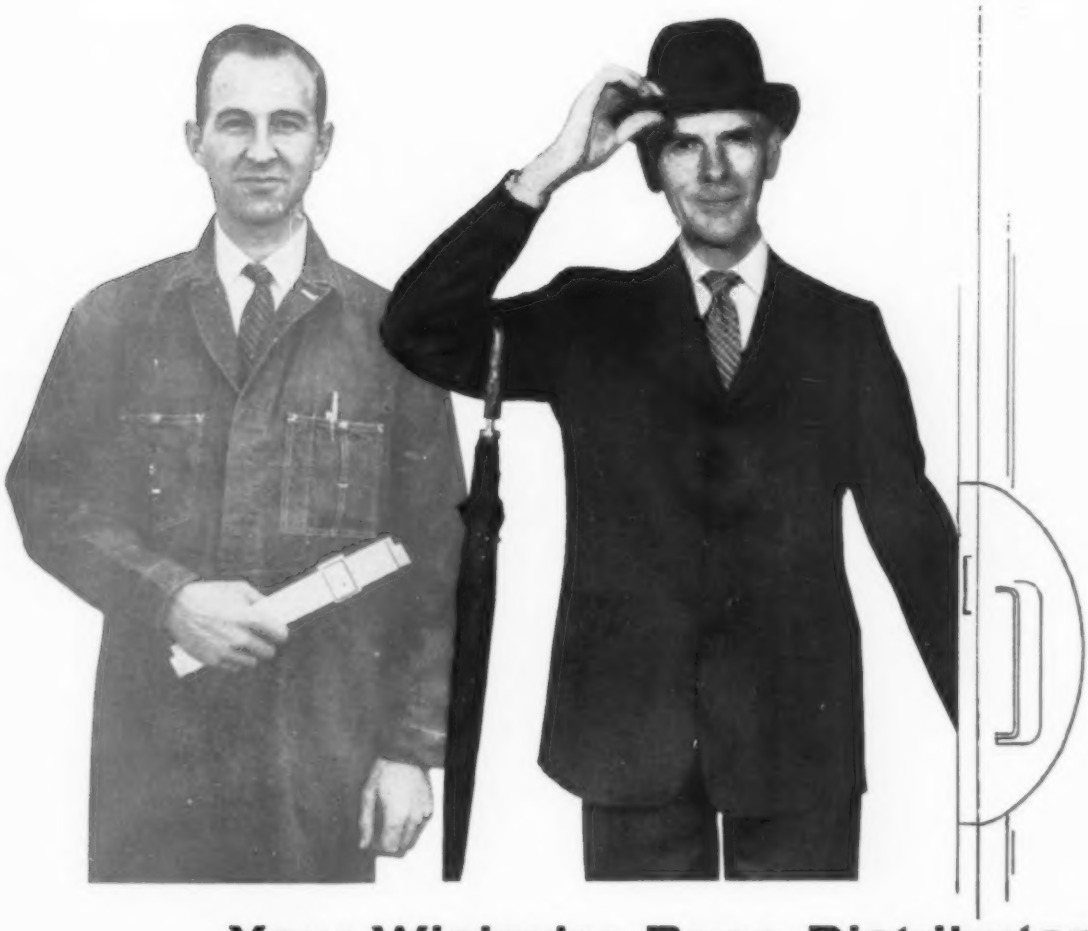

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True, sometimes he's hundreds of miles away, working in the field or at the mill. Yet, even if he's not there in person, your Wickwire Distributor has the full assurance that sales engineers such as this one are *always* quickly available to help you.

It's just one more reason why your Wickwire Distributor knows he's got top-quality wire rope, slings and strand to sell . . . and that these products will serve you well.

4086

A PRODUCT OF THE COLORADO FUEL AND IRON CORPORATION

What's doing in DRILLING

★ **Active rig count** continued to climb higher in March, in an attempt to near last year's mark. By March 11, combined U.S. and Western Canada working rigs totaled 2693 — far short of 1956 record for the same week of 2872. Hughes Tool Company reported 2494 active rigs one month earlier. No significant gains are being noted in any one particular section.

★ **California drilling notices** for the first two months of this year are ahead of last year, according to the California division of oil and gas. Through the week ended March 2, new well notices totaled 384, as against 376 in first 12 weeks of 1956. In this period, the division also reported 164 abandonments — 25 percent more than the year-earlier figure.

★ **New drilling is up in Texas,** as compared with 1956 activity. Through the week of March 11, the Railroad Commission reports, 3221 well completions have been made — nearly 200 greater than last year. Drilling applications in the state, however, are down, totaling only 4837, as against 5086 for the same period last year.

★ **No let-up in offshore drilling** has been noted as a result of renewed state-federal government talks concerning tidelands ownership. In Louisiana, over-water drilling wells in South Louisiana totaled 145 in mid-February. The number is increasing. Last year, for comparison, an estimated 125 drilling units were active in the same period. Breakdown by parishes list activity in this order: Plaquemines, 47; Cameron, 28; St. Mary, 18; LaFourche, 17; Terrebonne, 14; Jefferson, 10; Vermillion, 9; Iberia, 2.

★ **Venezuelan reports** of Creole Petroleum Corporation drilling reveal completion of 17 new wells in January. Creole completed 11 oil wells in the Bolivar Coastal field for an average daily production of 1693 bbl; two oil wells in Pilon averaging 300 bbl daily and one in Quiriquire averaging 355 bbl daily. One significant exploration well in the Bolivar Coastal field averaged 2547 bbl daily, completed from a productive depth of 9748 ft. Two other exploratory wells were completed in Urdaneta, averaging 150 bbl of oil daily at average total depth of 8174 ft.

★ **Oil and gas drilling** has been approved for 524 acres of West Los Angeles municipally owned and privately owned residential property as a result of a city council rezoning action. Acreage affected is adjacent to the 280-acre Twentieth Century-Fox Studio lot lease held by Universal Consolidated Oil Company. The company has completed 11 producing wells and is currently drilling a twelfth. Universal Consolidated may horizontally drill a 152-acre block just west of the studio. Signal Oil and Gas Company is asking to slant drill on the 144-acre Hillcrest Country Club nearby. Remaining surrounding leases, on which no acreage is being offered, covered a city owned golf course.

★ **Dixilyn Drilling Corporation,** Odessa, Texas, and **Barnwell Offshore, Inc.,** Shreveport, Louisiana, have ordered new offshore drilling units from R. G. LeTourneau, Inc. Estimated cost of each will be $2,500,000, with deliveries expected next fall. Dixilyn unit will have spuds 175 ft high, for 105 ft water drilling; Barnwell's platform will be able to drill in 80 ft water, outfitted with 145 ft spuds. Zapata Off-Shore Company received one of the units—its second—in March.

★ **Second submersible offshore giant** of the Rig 46 type has been placed in service by Kerr-McGee Oil Industries, Inc. New mobile unit, Rig 47, is starting a well on OCS-0474 No. 3 in Block 129-A of the Eugene Island Area, off St. Mary Parish, Louisiana, under contract to the Phillips Petroleum Company. Rig 47, built by American Bridge at Orange, Texas, and outfitted by the Ingalls Shipbuilding Corporation, Pascagoula, Mississippi, is an identical twin to Rig 46. The device is built of 14½-ft tubular members with outside dimensions of 242 by 202 ft, and has a weight on bottom of 5000 tons. Overall height, with mast erect, is 268 ft. The prototype of the design, Rig 46, has been moved to the location of its second well for the CATC Group.

Rotary Rigs Operating in Oil Fields of United States and Canada*

	Feb. 11	Feb. 18	Feb. 25	March 4	March 11
Alabama	6	7	9	13	14
Arkansas	14	14	17	16	18
Arizona	0	0	0	0	0
California	104	100	96	94	97
Colorado	36	39	41	43	42
Florida	2	2	2	2	2
Georgia	0	0	0	0	0
Idaho	1	1	1	0	0
Illinois	24	19	43	46	46
Indiana	0	0	4	1	3
Iowa	1	1	1	1	1
Kansas	150	158	152	162	169
Kentucky	3	5	7	4	7
North Louisiana	49	49	50	46	55
South Louisiana — Land	298	292	291	285	276
South Louisiana — Offshore	104	110	110	107	111
Total Louisiana	451	451	451	438	442
Maryland	1	1	1	1	1
Michigan	12	11	13	12	12
Missouri	0	0	0	0	0
Montana	23	23	25	30	27
Mississippi	17	14	21	21	21
Nebraska	30	28	28	27	31
Nevada	1	0	0	0	0
New Mexico	122	117	111	117	113
New York	0	0	0	1	1
North Dakota	21	18	19	23	27
Ohio	0	0	0	0	0
Oklahoma	209	238	232	245	239
Oregon	0	0	1	1	1
Pennsylvania	10	11	14	11	11
South Carolina	1	0	0	0	0
South Dakota	2	1	2	3	3
Tennessee	0	0	0	0	0
Texas Gulf Coast — Land	205	220	223	225	226
Texas Gulf Coast — Offshore	7	8	6	7	8
West Texas	370	373	354	383	400
North Texas	292	340	310	336	338
East Texas	54	56	57	60	56
Total Texas	928	997	950	1,011	1,028
Utah	32	33	34	35	34
Washington	1	1	1	1	1
West Virginia	2	1	1	1	0
Wyoming	46	45	49	49	52
United States	2,250	2,336	2,326	2,409	2,443
Western Canada	244	240	254	244	250
Grand Total	2,494	2,576	2,580	2,653	2,693

*As reported to the American Association of Oilwell Drilling Contractors by Hughes Tool Company.

Pouring Unaflo slurry into cell for tests at simulated well-bottom conditions. Such quality-control testing during manufacture accounts for Unaflo's consistently better field performance.

Quality control makes the difference in field performance of UNAFLO* oil-well cement

- Careful attention to product quality during the manufacture of Unaflo retarded oil-well cement pays off in down-the-well dependability.
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Drilling

★ **Drilling contractors in Israel** are now exempt from payment of sales and excise taxes on such locally-produced materials as cement and tires bought for oil exploration and development, the Government of Israel has announced. This is contained in a new amendment to the country's basic Petroleum Law of 1952. The amendment also grants drilling contractors exemption from customs duties, which, until now, was given only to companies holding oil licenses. New exemptions are all retroactive to April 1, 1954, the beginning of Israel's first complete year of oil development.

★**Georgia's attempts** at new production, being spurred by an offer of a state bonus of $250,000 seem to be getting little results. Georgia International Oil Company, however, is reporting activity at its No. 1 S. N. Winkler, 10 miles northeast of Preston in Marion County. The operators are moving in a larger rig over the old hole following cleaning up operations by a cable tool unit. Old hole was plugged back to 3500 ft, and may be deepened beyond the original total depth of 3990 ft. Last report indicated that crews have opened the old hole to a depth of 1800 ft.

★ **Air drilling** and aerated fluid drilling of Shell Oil Company well in Crittenden County, Kentucky, saved $98,000 and 129 rig days. The well was drilled to a total depth of 8821 ft. As a result of the well, several conclusions were reached about air drilling — at least for that particular location and situation: (1) hole can be air drilled dry or wet—but not damp drilled, because of sticking to the drillstem, (2) major bit problem was bearing life; some 90 percent of the bits pulled had bearing failures, and (3) dry air drilling rate was 400 percent better than mud-drilling rates and even with water in hole, it was 250 percent better than mud in comparable formations.

★ **Brack Drilling Company, Inc.,** Fort Collins, Colorado, is staking 14 new wildcat locations in Sioux and Box Butte counties on acreage farmed out by Continental Oil Company. This new spurt of activity in the Denver-Julesburg Basin is indicative of increased play in the area. Brack's projects are 10 to 30 miles north of Scottsbluff. First well to be drilled will be in Box Butte County, 20 miles northeast of Scottsbluff in C SW SW 5-24n-52w. Three of the new tests will go to the Morrison and 11 to the Skull Creek.

★ **Offshore Contractors, Inc.,** has positioned its mobile drilling platform Pacific Driller No. 1 off the California coast near Summerland to begin testing of the 5500-acre State lease held by Standard Oil Company of California and Humble Oil & Refining Company. The seagoing platform is drilling a deep core hole seeking further geologic information for the leasees on station about 1½ miles offshore and south of the town of Summerland. Depth of the water in that area is 76 ft. Pacific Driller No. 1 has a steel hull 100 by 200 ft and weighs 4000 tons. It has eight supporting elements 195 ft high, with actual drilling operations conducted 40 ft above the water.

★ **Permian Basin drilling contractors** met in Midland, Texas, March 13-15 for the sixth Conference for Drilling Executives sponsored by the American Association of Oilwell Drilling Contractors. The three-day management session was held at the Elks Club, according to Richard L. Dailey, conference coordinator. Dailey is with the Petroleum Extension Service of the University of Texas, which conducts the executive meetings. Conference leaders were M. L. Powers, director of business and industrial services for the University of Oklahoma, and W. K. Powell, cost accounting consultant and president of Beard Drilling Company, Duncan, Oklahoma.

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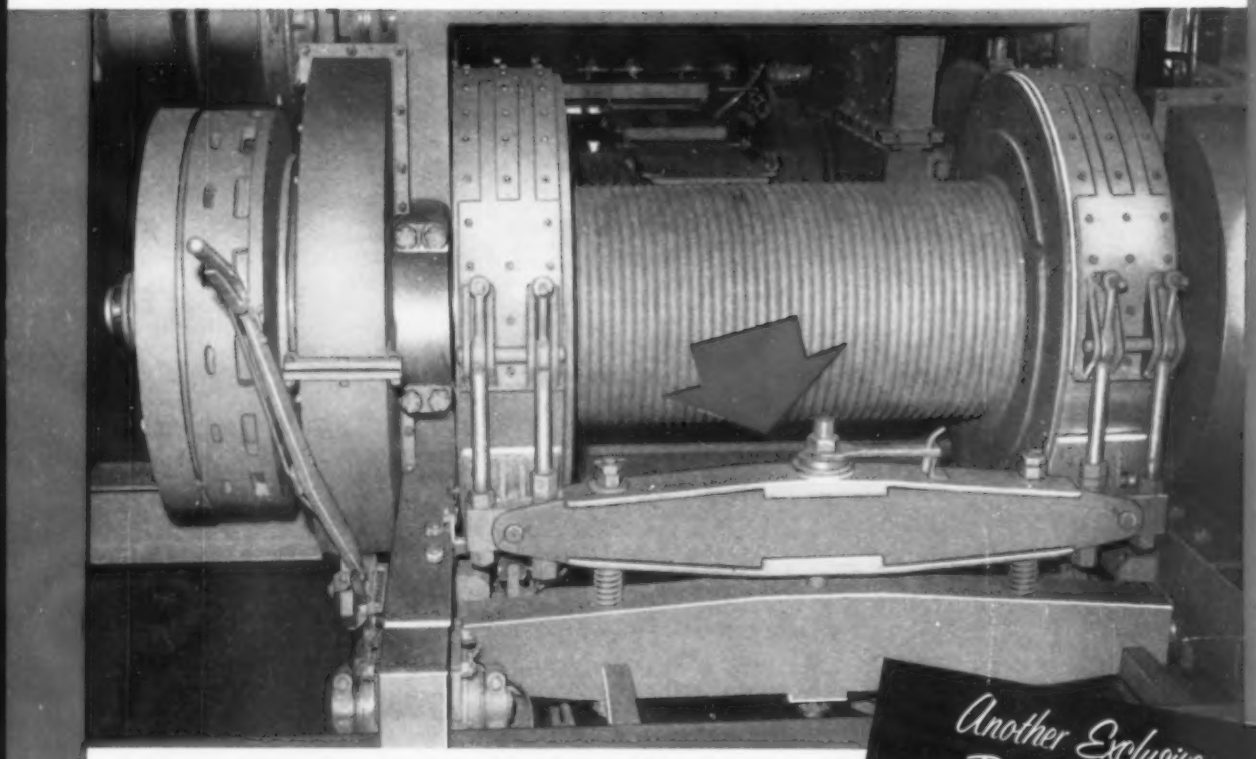

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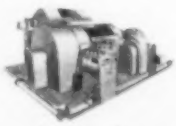

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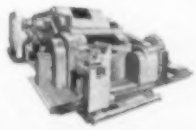

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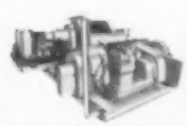

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▸ The AAODC has added four new directors to the board. They are: **Donald J. Gillespie,** Glenn Gillespie and Sons, Cushing, Oklahoma; **William C. Kneale,** Rimrock Tidelands, Inc., New Orleans; **Arthur Stout,** McQueen & Stout, Midland, Texas; and **Earl G. Bateman,** Bateman Drilling Company, New Orleans.

▸ **E. E. Tucker** of Houston, Texas, has been promoted to production manager of Tidewater Oil Company's southern division. Formerly, he was assistant division production manager for Tidewater's southern division.

▸ **Robert S. Haigh** has been promoted to district geologist of the Bismarck (North Dakota) production and exploration district of Lion Oil Company, a division of Monsanto Chemical Company. He replaces **Ray L. Harrison, Jr.,** who recently resigned.

▸ **Stephen L. Drake** of Odessa, Texas, has been promoted to a new position with Sinclair Canada Oil Company, Calgary, Alberta, Canada. He is to be district production foreman. He was formerly assistant district foreman for Sinclair Oil & Gas Company, parent organization of Sinclair Canada.

▸ **Franklin B. Baker,** petroleum engineering graduate of Montana School of Mines, Butte, Montana, was a first place award recipient in the fifteenth national student prize paper contest of the AIME.

▸ **Clarence Eugene Whipp, Jr.,** has joined Trunkline Gas Company of Houston, Texas, as district geologist for the Southern Louisiana district. His headquarters will be in Lafayette, Louisiana. He joined Trunkline Gas from Highland Oil Company. His experience includes being a geologist with Sohio Petroleum Company and Louisiana Geological Survey.

▸ **J. L. Hoyt,** formerly general superintendent for Pan American Production Company with headquarters at Houston, Texas, has been transferred to New Orleans, Louisiana, where he is now district superintendent for Pan American Petroleum Corporation (formerly Stanolind Oil and Gas Company). Hoyt's transfer to his new post was made after Stanolind and Pan Am were merged and the company name changed.

▸ The Denver Landmen's Association has elected the following officers and directors: **Hugh O. Post,** president, Union Oil Company of California; **Jess Tyra,** first vice president, Sunray-Mid Continent Oil Company; **Keith Bennett,** second vice president, Continental Oil Company; **Joe Mills,** secretary, Sinclair Gas & Oil Company; and **Bruce Craig,** treasurer, Kewanee Oil Company. Directors are: **Joe B. Morris,** Lion Oil Company; **R. A. Follansbee,** Murphy Corporation; **Paxton Robertson;** Sun Oil Company; **J. Warren Smith,** Gulf Oil Corporation; **George Harris, Jr.,** Shell Oil Company, and **Eugene Dines, Jr.,** Midwest Oil Corporation.

▸ **Earle F. Taylor** has been named president of the new T.U.L.M. Corporation. He was formerly with DeGolyer and MacNaughton and served as member of its board of directors and a senior vice president. He also held various executive posts with three of that firm's subsidiaries.

E. F. Taylor

▸ **John A. Masters,** formerly manager of uranium exploration, Tulsa, Oklahoma, heads a new exploration office, Calgary, Alberta, Canada, for Kerr-McGee Oil Industries, Inc. District geologists are **Gerald C. Loucks** and **Robert L. Duncan.** Loucks was with Skelly Oil Company in southern Oklahoma and Duncan was southwestern Louisiana area geologist for The California Company in New Orleans.

▸ **C. M. Hartwell** of Houston, Texas, has been appointed district superintendent for Cities Service Oil Company's production operations in Mississippi and Louisiana. He succeeds **M. A. Reber** of Lafayette, Louisiana, who has been named manager of operations for Dhofar-Cities Service Petroleum Corporation. Hartwell was serving as marine superintendent at Houston at the time of his promotion. Reber was appointed district superintendent for Mississippi and Louisiana in 1952.

▸ **J. P. (Jack) Johnson** has been named drilling superintendent of the Penrod Drilling Company, Shreveport, Louisiana.

▸ **Harold E. Jones** has been named division geologist in Midland, Texas, for Bankline Oil Company. He takes the place formerly filled by **William B. Dansfield,** who recently resigned to work as a consultant.

▸ **George N. Wilson, Sr.,** district engineer, has been promoted to the recently created position of assistant superintendent for the Midland production district of Seaboard Oil Company. **Alva G. Walsh,** staff engineer, is the new district engineer.

▸ **W. E. Haggard,** Houston, Texas, has been promoted to the newly created position of manager of operations for Continental Oil Company's western region, with headquarters in Los Angeles, California. He formerly was manager of the company's headquarters land section at Houston.

▸ **Don R. Teis,** formerly with the Petroleum Administration for Defense, Washington, D. C., and the Lawton Oil Corporation, Magnolia, Arkansas, is now associated with Foree Drilling Company, Dallas, Texas.

▸ **Wayne E. Swearingen,** chief engineer for Alex W. McCoy Associates, Inc., has been elected vice president for engineering. **Dr. Carl Moritz,** executive vice president, has been appointed chief geologist to coordinate the independent firm's geological consultant work.

▸ **Whitney M. Elias,** vice president and manager of Pan American Petroleum Corporation's Texas-Louisiana Gulf Coast division, has been elected to the advisory committee of the board of directors, Bank of the Southwest.

▸ **Howard R. Ritzma** has opened offices as consulting geologist in Denver, Colorado. He was formerly employed as Rocky Mountain district geologist for Southern California Petroleum Corporation.

▸ **Fred H. Plitt** has been named staff engineer at the general offices of Southwest Gas Producing Company, Inc., Monroe, Louisiana. He was formerly with Carter Oil Company.

The 1957 executive officers of the CIM-AIME Petroleum Engineering Section at Calgary, Alberta, Canada, are: Front Row—R. R. McDaniel, McDaniel Consultants, Ltd., first vice chairman; E. M. Barlie, Petroleum & Natural Gas Conservation Board, chairman; S. G. Gary, Core Laboratories of Canada, Ltd., second vice chairman; C. J. Taylor, Baker Transworld, Inc., director; G. M. Kernahan, McCullough Tool Company, secretary-treasurer; J. B. Maughan, Pan American Petroleum Corporation, director; and John Peake, Pembina Engineering Committee, director.

Officers and directors of the Denver, Colorado, section of the Society of Petroleum Engineers, AIME for 1957 are: (left to right) John Ferry, E. A. Polumbus, Jr. and Associates, first vice chairman; Jim Edwards, McCullough Tool, second vice chairman; John Banister, Halliburton, secretary-treasurer; Fred Poettmann, Ohio Oil, director; Marvin Owen, Central Bank, director; and Paul Grimm, The Texas Company, president.

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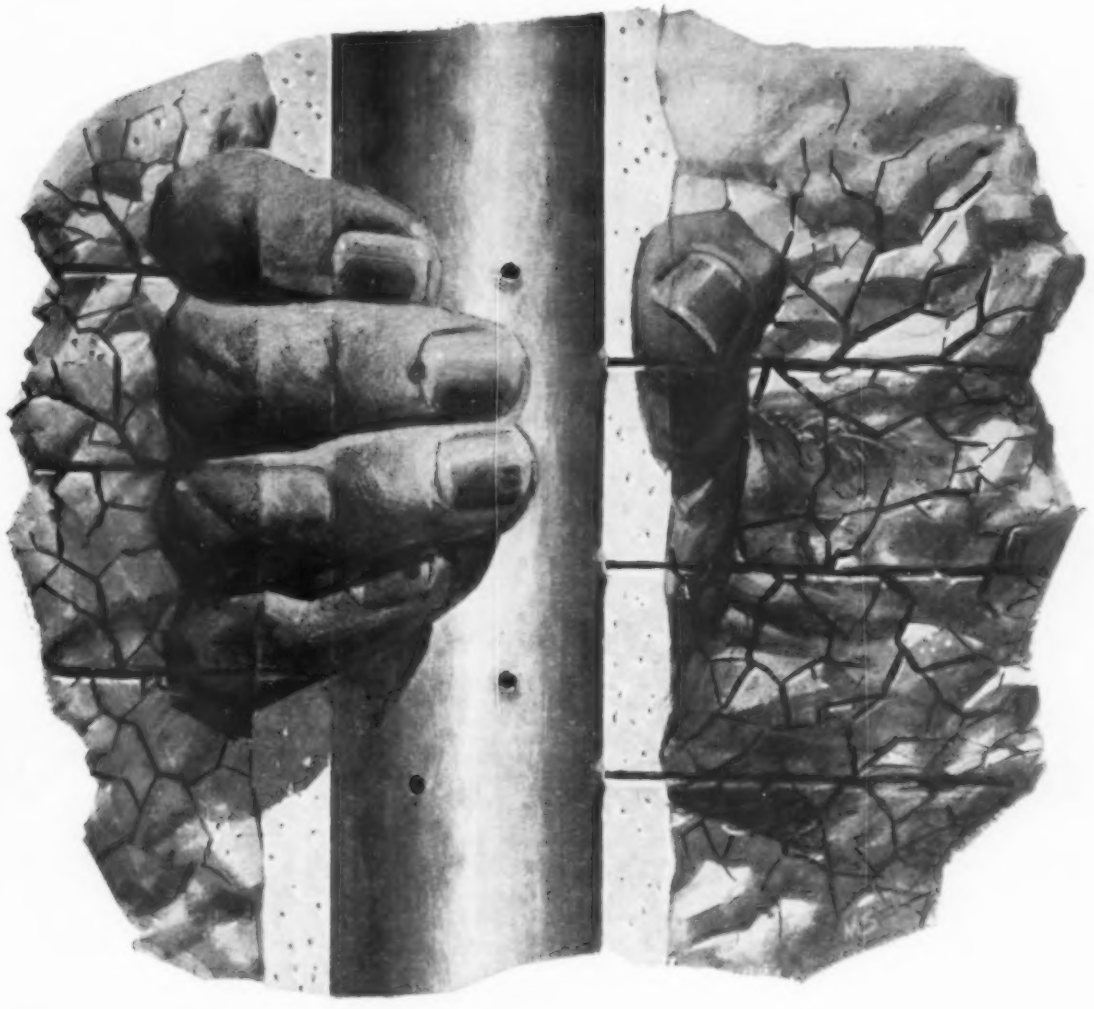

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▸ The following officers were elected at the annual meeting of the directors of Petroleum Production Pioneers, held in the Petroleum Club of Los Angeles, January 28, 1957: **Ben E. Parsons,** honorary president, General Petroleum Corporation, retired; **Frank R. Seaver,** honorary vice president, Hyril Corporation; **Fremont R. Schnieder,** president, Shell Oil Company; **T. H. Wallace,** vice president, Western Gulf Oil Company; **Douglas G. Kingman,** treasurer, General Petroleum Corporation; **R. Sneddon,** secretary, Petroleum Club of Los Angeles; **Paul Andrews,** historian, Signal Oil & Gas Company; and **Thomas E. Morton,** sergeant-at-arms, Halliburton Oil Well Cementing Company.

▸ **R. A. Bishop,** northwest division geologist, has been transferred to Oklahoma City, where he is assuming the position of staff assistant-exploration for Sohio Petroleum Company. Replacing Bishop is **Dr. A. C. Munyan,** who is transferring from staff geologist, northwest division.

▸ **T. J. Jeffrey** has opened petroleum engineering consulting offices in Dallas, Texas. He has been engaged in consulting work with J. A. Lewis Engineering, Inc., and The Atlantic Refining Company.

T. J. Jeffrey

J. M. West

▸ **Jack M. West** of Corpus Christi, Texas, has joined Cosden Petroleum Corporation as landman for the South Texas division. He was formerly district landman for the Spartan Drilling Company.

▸ **Gayle P. Crawford** has joined United States Smelting, Refining & Mining Company as division geologist in charge of the geological department. He was formerly senior geologist with The Superior Oil Company.

▸ **H. L. Scott,** former assistant zone superintendent for Gulf Oil Corporation at Harvey, Louisiana, has been transferred to the Mene Grande organization, a Venezuelan affiliate of Gulf Oil. His replacement at Harvey has not yet been announced.

▸ **Jack A. Taylor** has been transferred from the geological department in Lake Charles, Louisiana, to Mount Vernon, Illinois, where he is now district geologist of the Illinois district for Magnolia Petroleum Company.

▸ **James H. Butler** and **Rex H. Richardson,** both of Midland, Texas, have formed a partnership to deal in oil properties. Prior to establishing their own business, the partners were with W. E. Bakke, Butler as district geologist and Richardson as manager of the land department.

▸ Formation of The Secondary Recovery Corporation of Texas has resulted in the election of **William F. Wallace, Jr.,** as president and **Leo E. McCloskey** as vice president. Wallace was attorney in Corpus Christi, Texas, and McCloskey was chief engineer of The Chicago Corporation. The company will be headquartered in Corpus Christi.

▸ **R. L. Harris** has joined Northern Natural Gas Producing Company as production engineer. He was associated with Sinclair Canadian Oil Company at Calgary as a petroleum engineer prior to joining Northern Natural Gas Producing, a subsidiary of Northern Natural Gas Company.

▸ **Dr. Hal P. Bybee,** University of Texas geology professor and consulting geologist to the University Lands, has been awarded honorary membership to the Association of Petroleum Geologists. The award was made in recognition of Dr. Bybee's great effort in building the university's permanent endowment fund by developing oil and gas production on university lands.

▸ **Coles S. Tinkler,** senior landman for the Midland division of Sinclair Oil & Gas Company, has been promoted to division exploration superintendent at Midland, Texas. He was named senior landman at Fort Worth, Texas, 1955, and was transfererd to Midland a year later.

▸ Four Texas oilmen have been presented Citations for Service for outstanding contributions to the industry and the API. They are: **Levi Shiplet,** The Texas Company; **C. R. Athy,** Maxwell Steel Company; **M. R. Hayes,** Phillips Petroleum Company, and **J. W. Hall,** Durham Drilling Company.

▸ **Ralph O. Dietler,** independent oil consultant, has been named director and vice president of Frisbie Drilling Company of Tulsa, Oklahoma. He is the former president and chairman of Stanolind Oil Purchasing Company (now Indiana Oil Purchasing Company).

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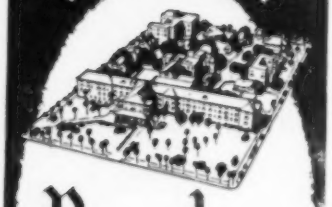

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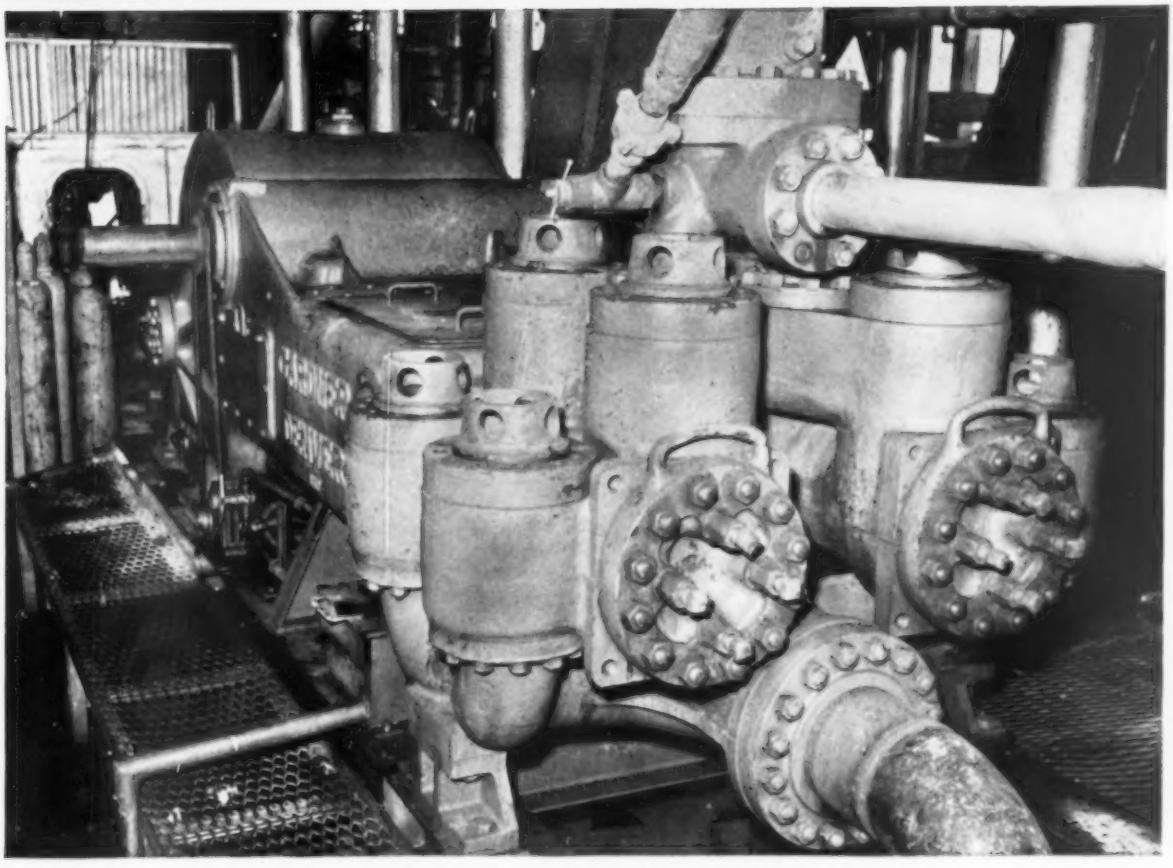

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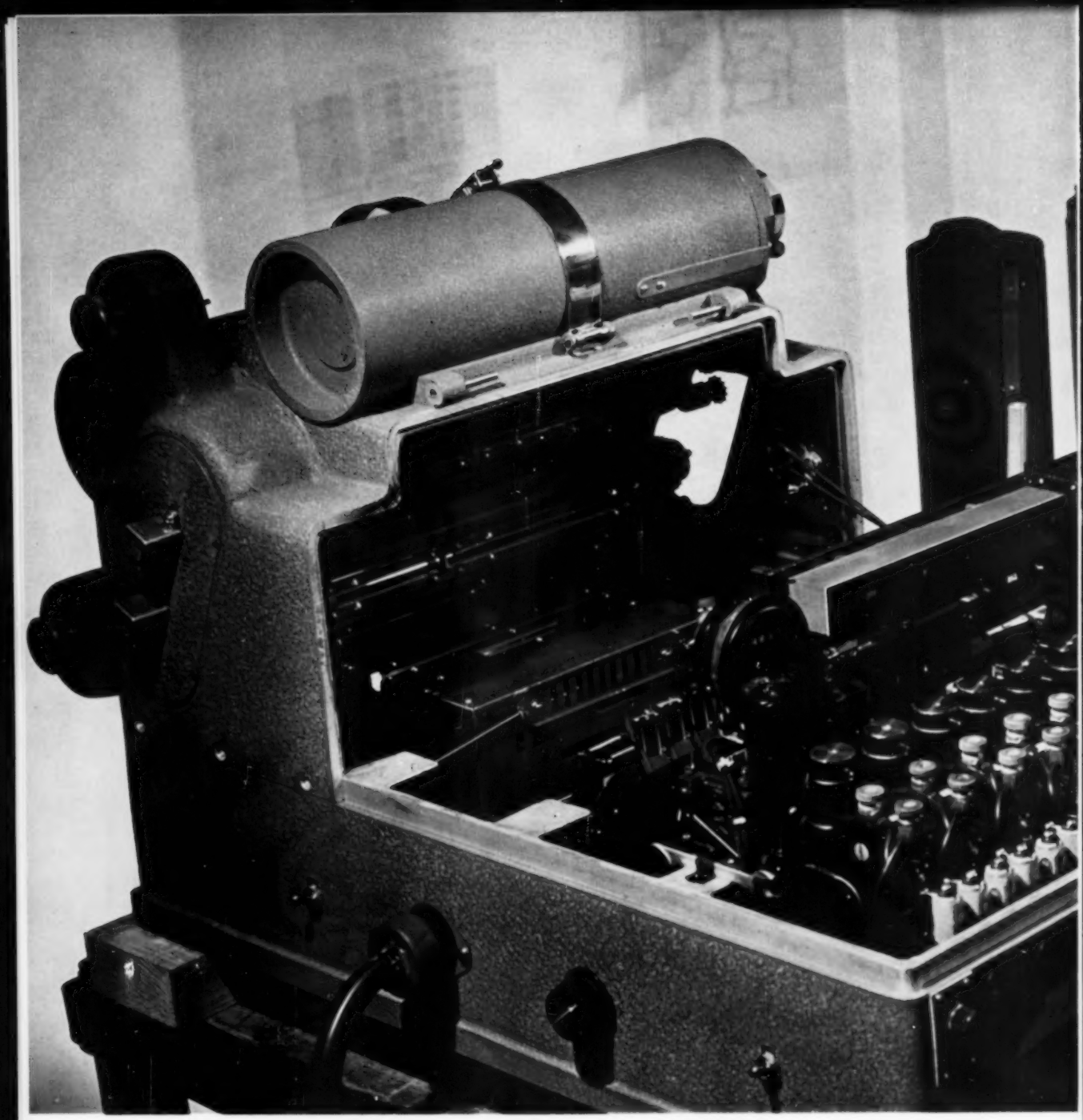

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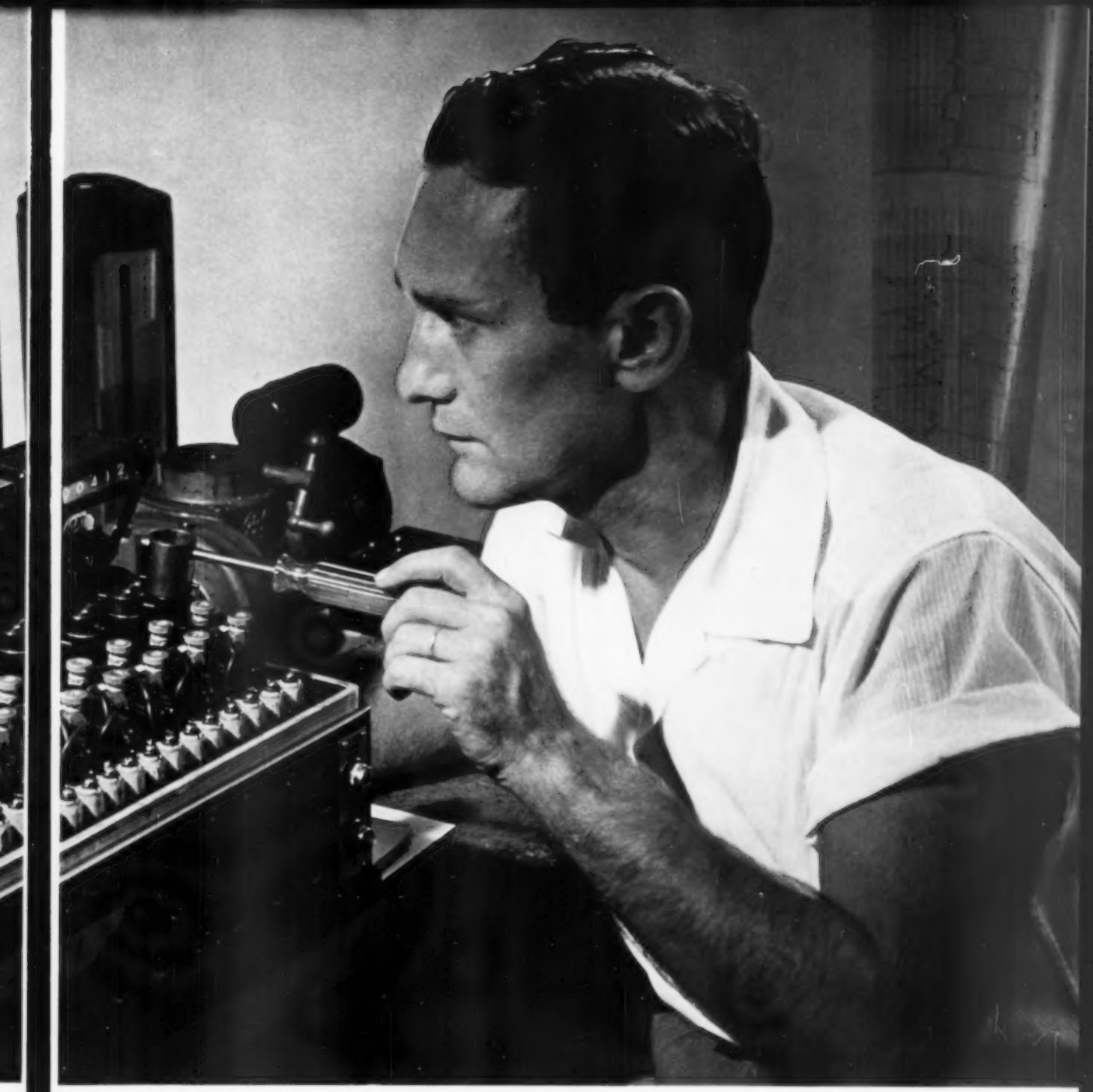

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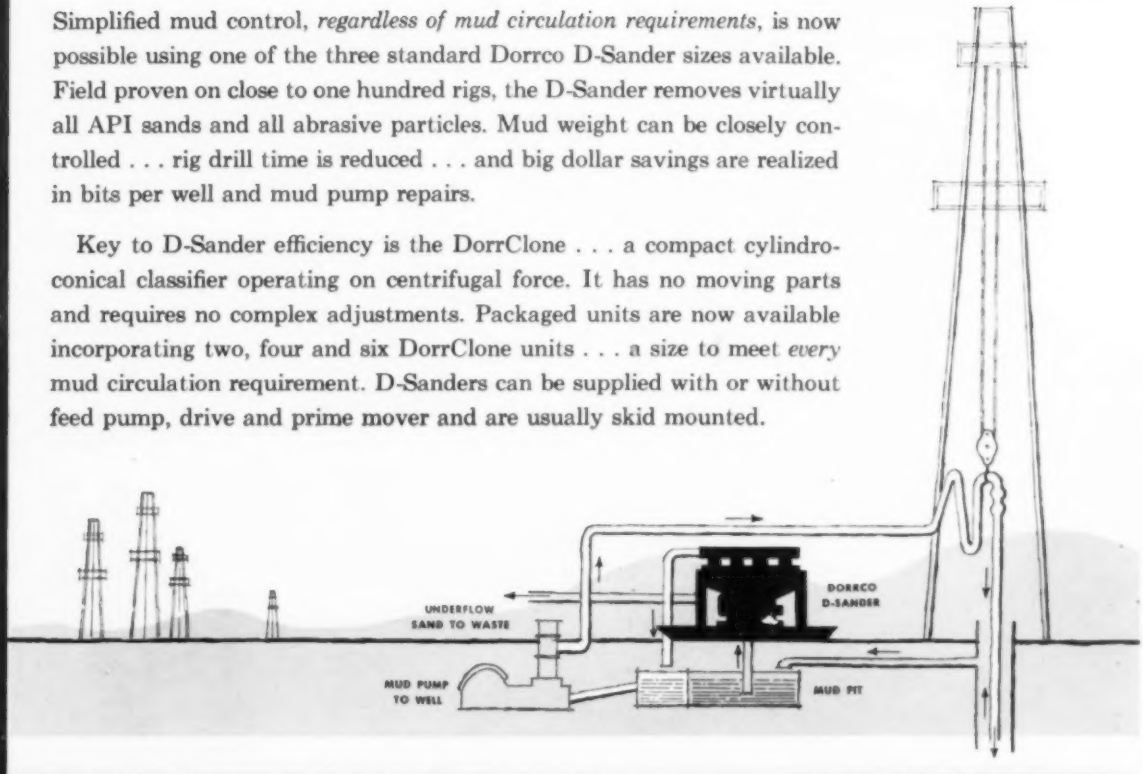

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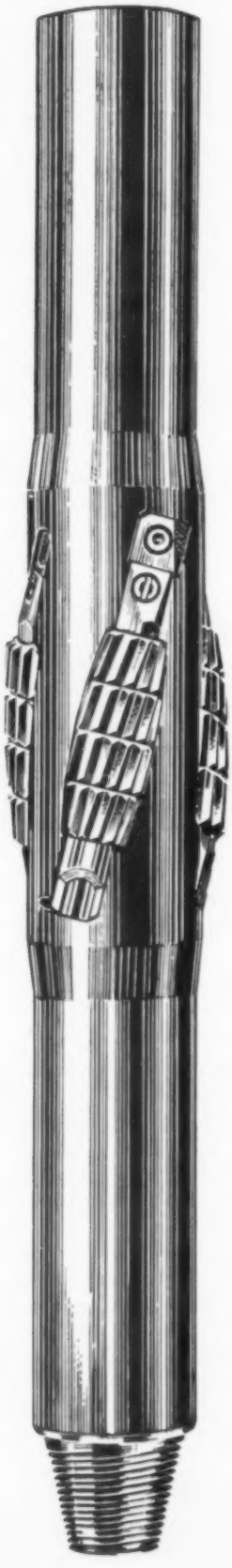

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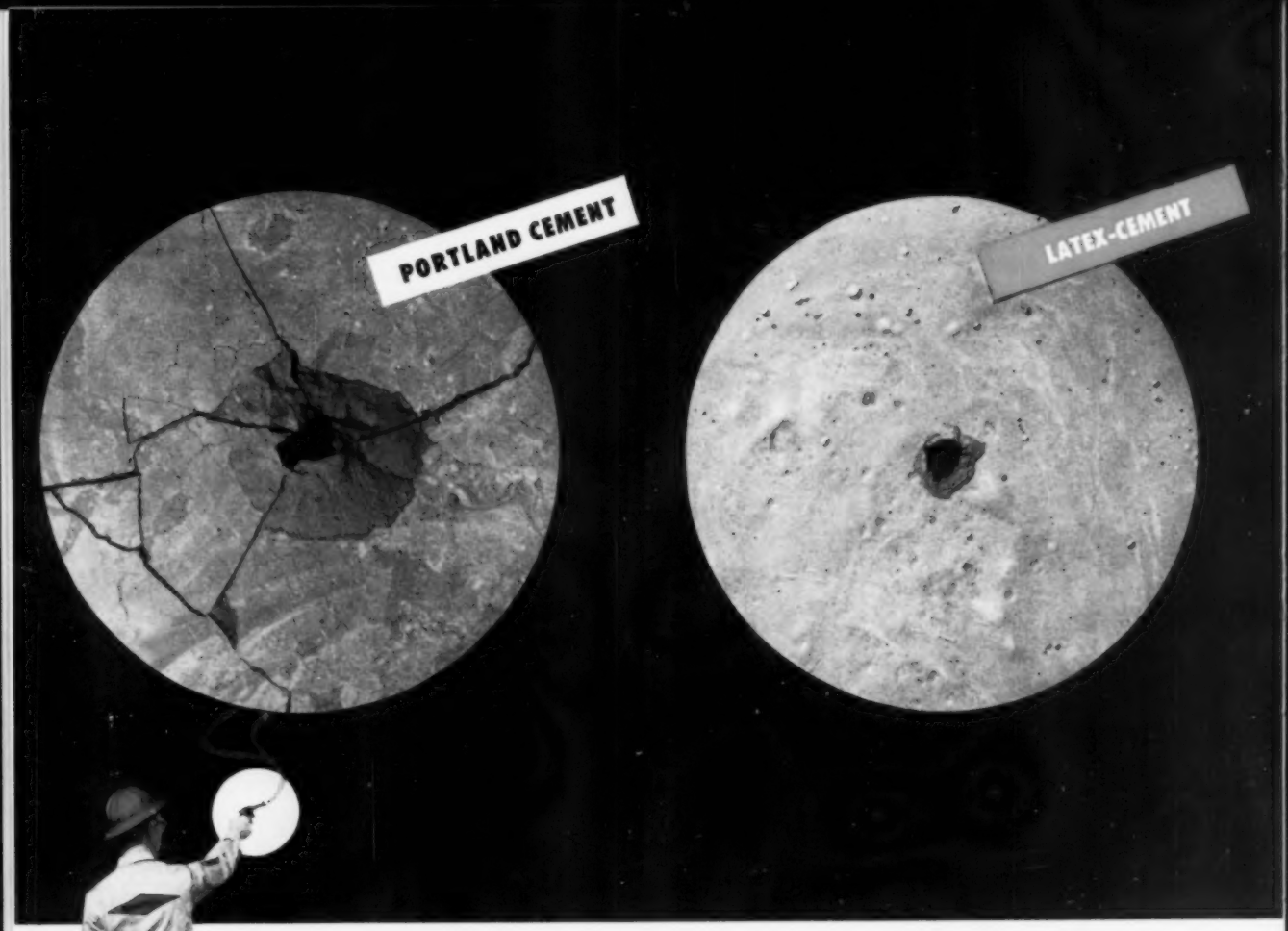

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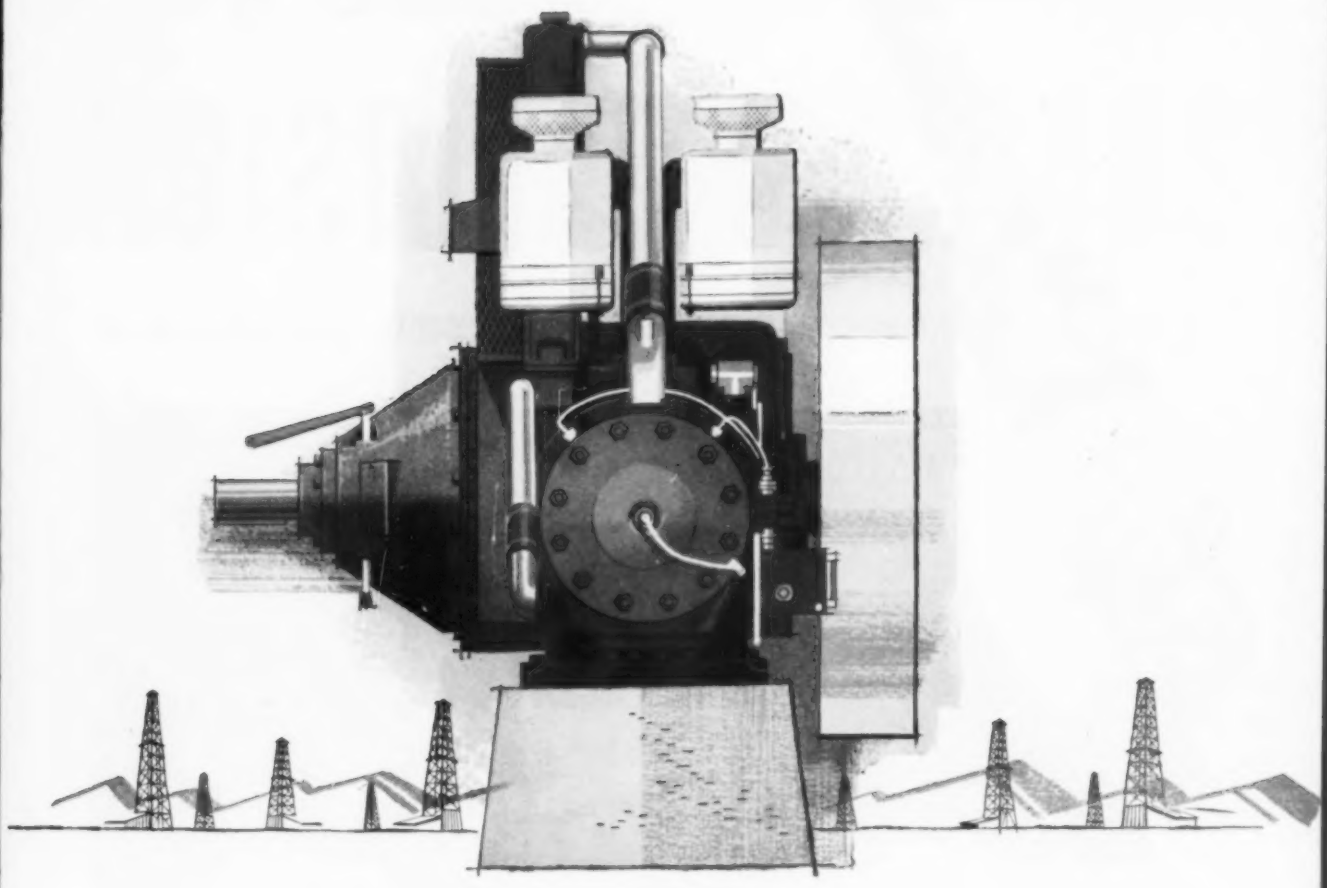

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always producing prime movers and pumps a
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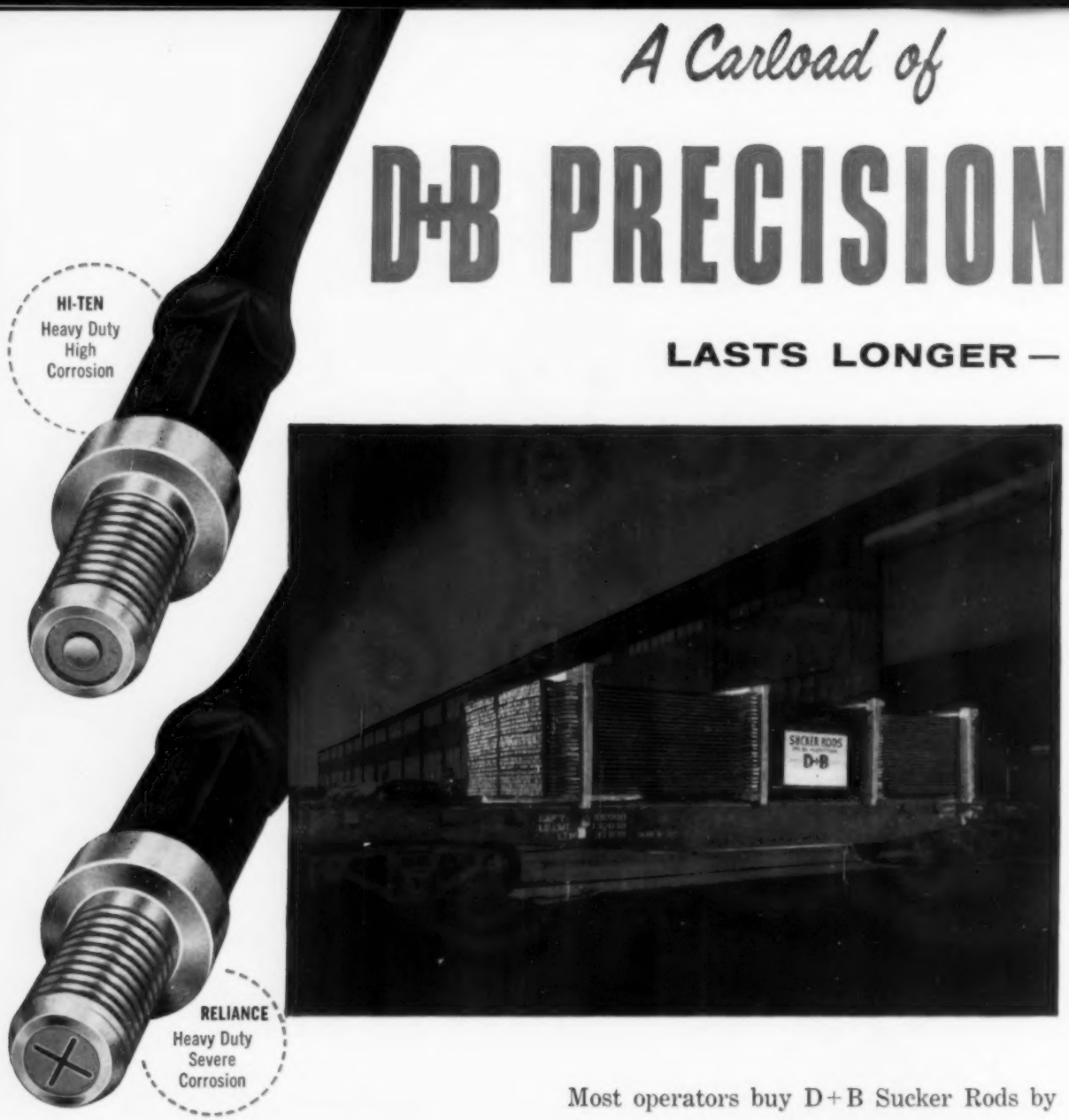
A Carload of

D+B PRECISION

LASTS LONGER—

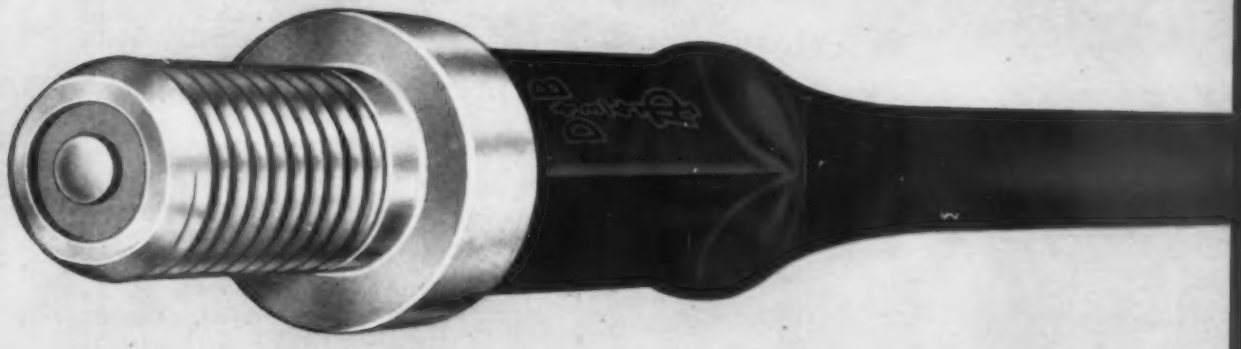


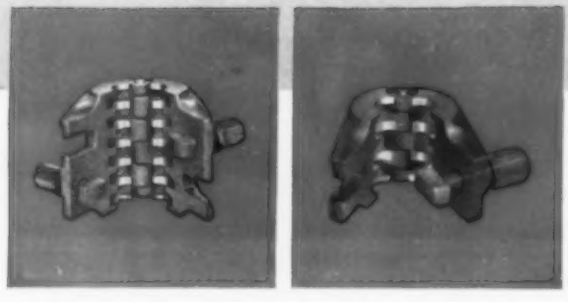
Most operators buy D+B Sucker Rods by the carload—some buy many cars—because they have more hours of actual pumping life, save the operator time and money, and cut down-time to a minimum.

Precision manufacturing, the best scientifically controlled materials, careful inspection and shipping, and 50 years of experience, stand back of every D+B Sucker Rod. Is it any wonder they stay in the hole longer?

-BUILT SUCKER RODS

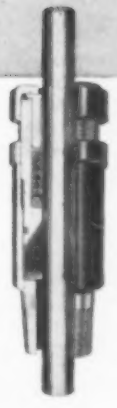
RESISTS CORROSION — CUTS DOWN-TIME!





D+B KWIK-GRIP® ROD CLAMPS
—FOR ONE-MAN INSTALLATION

Eliminates "knuckle busting." Easy quick opening is provided by a quarter turn of Tee-head permitting special forged bolt to slide through slot to remove clamp. Meets API specifications for pulling load.



D+B DUAL-PAC® STUFFING BOX
—A MAJOR TIME SAVER

Use of dual packing permits replacing the pressure seal packing easily without killing the well. Due to superior design, the higher the well pressure, the tighter the seal. Exceptionally wear resistant.

Get all the facts today about D+B Sucker Rods—the life line of the oil pumping business. Call or see your nearby Continental-Emsco store.

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Tough, versatile, tremendously dependable, this offshore supply vessel — one of four built by Ingalls for Sea Service Incorporated—is indeed an "all-purpose packhorse" for the big offshore rigs! Capable of carrying 3,500 barrels of water — or two enormous stacks of 8" drill pipe — *plus* 2,000 gallons of drinking water and miscellaneous stores and equipment, she also boasts a pair of 516 h.p. Buda diesel engines. Able to maintain a speed of 11 knots, she is used to tow drilling barges on location, and as a standby tug. The know-how in the offshore drilling field depends on EQUIPMENT know-how; Ingalls has it, and is glad to help *you* with it! The Ingalls Shipbuilding Corporation cordially invites your inquiry.

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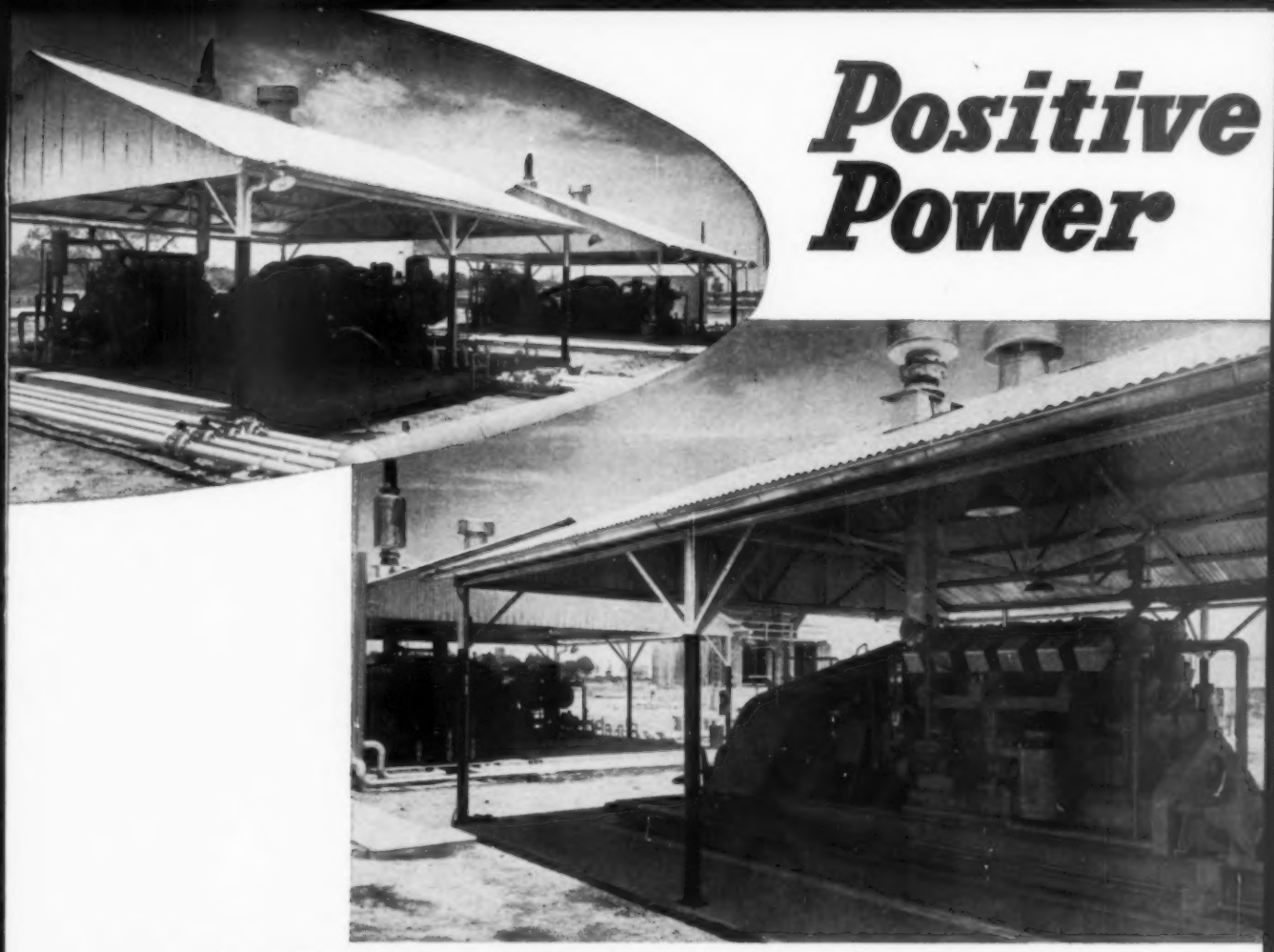
Positive Power



When positive power is needed 24 hours a day every day of the year, Climax Blue Streak Engines deserve first consideration. Dependability, economy, and a well established reputation have brought Climax Engines to their present leading position as power suppliers for oil and gas installations. The two Climax V-122's shown above are each driving a compressor for Republic Natural Gas Co. on their O'Connor lease, producing 1,500,000 cubic feet of gas per day, every day. On the coast, in the mountains, or on the plains, you'll see these Climax Blue Streak Engines operating efficiently throughout the oil country.

Get all the facts on Climax Oil Field Engines from your nearby distributor today.

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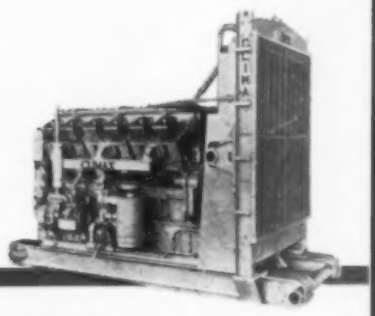
climax BLUE STREAK ENGINES



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The "Cone Nebula" in the constellation of Monocerus photographed through the 200-inch Hale telescope of the Palomar Observatory. This mass of stars is about 1,000 light-years, or roughly six million billion miles from the earth.

MEASURING THE UNSEEN

Although attempting nothing so spectacular as measuring unseen stars through a 200-inch telescope, Tuboscope research is paying off for oil men everywhere. From Tuboscope research have come new instruments for measuring the nearly unseen effects of wear, fatigue, and corrosion in oilfield tubular goods. And from Tuboscope experience in the field comes the ability to inspect and to grade your tubular goods with the greatest possible precision and with the least chance for human error. The important factors of bottom hole pressure and temperature are measured by Tuboscope's Subsurface Engineering Division.

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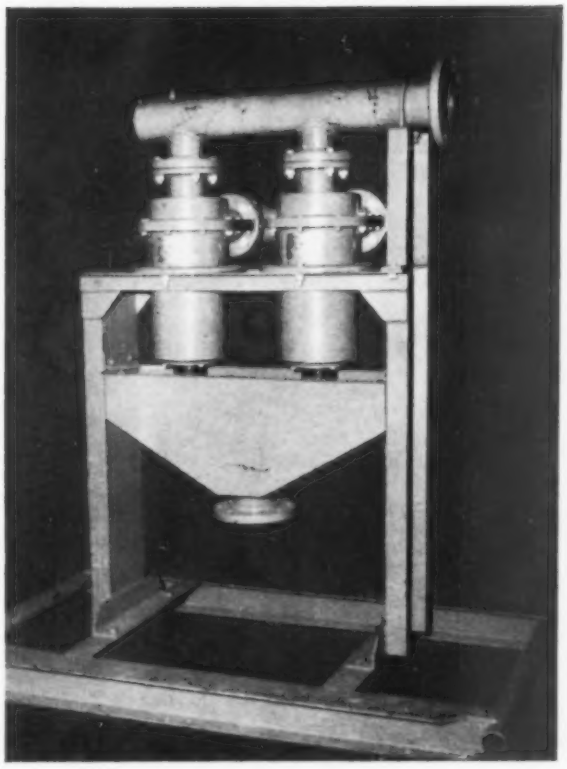
3-1

HERE IT IS...
a new 2-DorrClone
Dorrco
D-Sander

—designed especially for hard formation drilling



The new Size 2 Dorrco D-Sander is low in both first cost and operating cost. In addition, it is light in weight and easy to move. Designed especially for hard formation drilling with any rig, or slim hole drilling in a wide variety of formations, it brings the benefits of drilling fluids substantially free of drilled solids within the reach of every operator.

The benefits from using Dorrco D-Sanders are many. In many fields along the Gulf Coast, as well as other areas, abrasive sand can seriously reduce the life of bits and pump parts unless a D-Sander is used. In addition, the high viscosity of mud laden with drilled solids reduces drilling rates as much as 25 per cent.

In these areas, important savings in drilling costs result in that section of the hole where unweighted mud can be used.

But recent experience has proved that savings can also be realized in many other areas where abrasive formations are not encountered. In these areas, "flour sand" Dorrco D-Sanders, set to remove all drilled solids above 30 microns in size, result in greatly improved drilling speeds—sometimes in excess of 15 per cent.

In harder formations, drilling rates are slower and drilled solids are produced at a lower rate. In many of these areas, the Size 2 D-Sander, which provides capacities up to 250 gpm, is entirely adequate, yet it costs less to buy, to move and to operate than larger units.

The new Size 2 D-Sander compliments the capacity ranges of the larger sizes 4 and 6. With this new addition, Swaco offers units suitable for any rig and any drilling condition. Write for full information.

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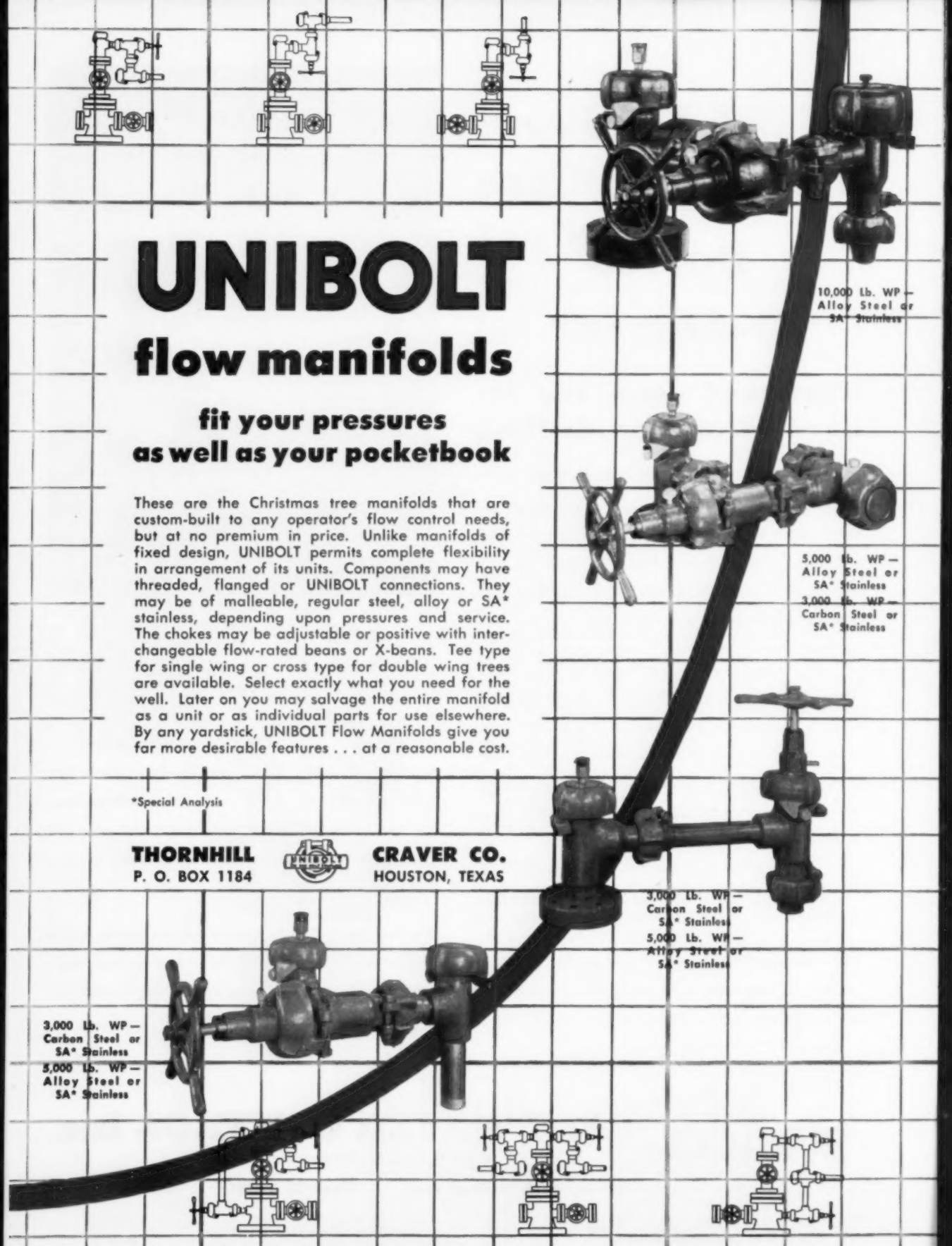
These are the Christmas tree manifolds that are custom-built to any operator's flow control needs, but at no premium in price. Unlike manifolds of fixed design, UNIBOLT permits complete flexibility in arrangement of its units. Components may have threaded, flanged or UNIBOLT connections. They may be of malleable, regular steel, alloy or SA* stainless, depending upon pressures and service. The chokes may be adjustable or positive with interchangeable flow-rated beans or X-beans. Tee type for single wing or cross type for double wing trees are available. Select exactly what you need for the well. Later on you may salvage the entire manifold as a unit or as individual parts for use elsewhere. By any yardstick, UNIBOLT Flow Manifolds give you far more desirable features . . . at a reasonable cost.

*Special Analysis



10,000 Lb. WP — Alloy Steel or SA* Stainless

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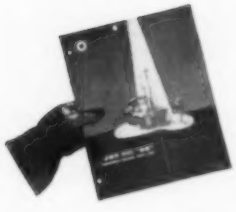
THE *Joy 35* SHOT HOLE RIG... MOVING FAST



Get complete details on the 35-C. Write for bulletin 152-83

A shot hole rig has to get around . . . has to get in . . . get the hole down . . . and get out. That's the Joy "35". It's lightweight—extremely portable . . . mounted on a short wheelbase truck, it gets in anywhere. It gets hole down fast because it's the only rig of its size that has four speeds forward . . . gives you just the right speed for the formation being drilled to get the fastest penetration. And the Joy "35" stays on the job. The entire machine is built as a group of unit assemblies . . . each of which can be replaced or exchanged independently.

Find out more about the rig that is moving fast—the Joy "35" . . . write ***Joy Manufacturing Company, Oil Field Drill Division, P.O. Box 35326, Airlawn Station, Dallas 35, Texas.*** In Canada: *Joy Manufacturing Company (Canada) Limited, Galt, Ontario.*

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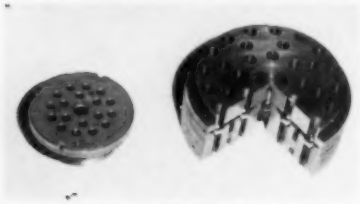
Denver, Colo.; Salt Lake City, Utah; San Francisco and Los Angeles, Calif.; El Paso, Texas; Carlsbad, N.M.

Baash-Ross Tool Co. Div.—Abilene, Corpus Christi, Houston and Odessa, Texas; Harvey, New Iberia and Shreveport, La.; Ardmore and Oklahoma City, Okla.; Avenal, Bakersfield, Long Beach, Newhall, Taft, and Ventura, Calif.; Casper, Wyo.; Hobbs and Farmington, N.M.; Olney, Illinois.

Export Sales—Joy Manufacturing Company, 60 E. 56th St., New York, N. Y.

NEW Drilling and Producing Equipment

New Compressor Valve for Air and Gas. A new concept in compressor valve design has been introduced by the Ball Valve Company. Designated the BV valve, it uses the ball check valve principle instead of the plate valve technique widely

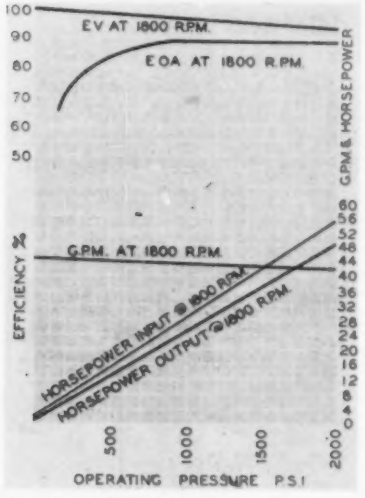


used at this time. Design uses a multitude of spring-loaded check valves built into the valve body. Advantages to the petroleum industry indicated by manufacturer are simplicity of design; streamline flow for greater valve efficiency; reliability in that instantaneous failures can not occur; and lower maintenance costs due to ease in reconditioning of valve and greater valve life. Valves are designed for use in compressors in the refining, gas processing, and gas transmission industries as well as air and gas drilling. *The Ball Valve Co.*

Circle number (1) on reply card.

New 2000 Psi Vane Pump. Series of balanced vane hydraulic pumps for continuous 2000 psi service has been introduced by the Denison Engineering Division, American Brake Shoe Company. The "T" series, pumps feature hydraulically balanced vanes and are offered with deliveries of up to 100 gal per min at speeds up to 1800 rpm.

Two bolt threaded flanges are provided as standard equipment but four bolt hydraulic connections are available for those desiring to use SAE four bolt split flange connectors. A nose type shaft seal, de-



signed to withstand inlet pressures up to 100 psi gage, provides a positive type seal with considerably longer life than the lip type seal. This pump may be face, foot or flange mounted in any of four positions on its mounting bracket. *Denison Engineering Division, American Brake Shoe Company.*

Circle number (2) on reply card.

All-aluminum Derrick. Telescoping derrick and its accessory well-servicing equipment are virtually all-aluminum. Weigh-

ing about one-third less than an all-steel unit of similar capacity, it offers a solution to the problem of transporting such equipment over public highways. The portable unit features not only an all-aluminum derrick but also an aluminum bed, winch frame, guards, cab, wheels, and truck bogie. *Franks Division, Cabot Shops, Inc.*

Circle number (3) on reply card.

New Air Drilling Compressor. New, 1200 cfm air drilling compressor, belt-driven from the rig's compound, utilizes the available rig power through 7 v-belts for each compressor. Compressor can also be driven by independent power mounted on

a common skid base. Recommended for oilfield use, unit is skid-mounted and self-contained, with its own cooling system.

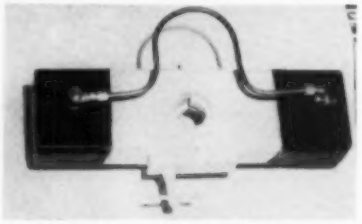
The Model 1200 requires 320 hp at the flywheel. When 2 compressors are used, at least 1000 hp is recommended to provide sufficient air power for other rig requirements. *Petroleum Division of Schramm, Inc.*

Circle number (4) on reply card.

Pressuring Tool Reduces Casing Failures. A new tool allows casing to be pressure tested before cementing. A drillable "dough-nut" seal is placed above the float collar or shoe and casing is run and circulated in the usual manner. A "plug" is circulated, immediately prior to running cement, which seats in the "dough-nut" and allows the casing to be pressure tested. "Plug" is retrieved with the sandline. *Macro Limited.*

Circle number (5) on reply card.

Device Saves Stuffing Box Packing. Device serves a dual purpose in connection with pumping wells. It is designed so that the spring loaded polish rod brighteners



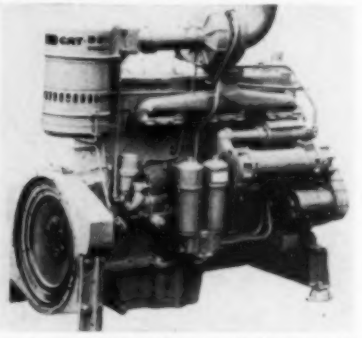
rid the polish rod of corrosion deposits. There are reservoir compartments that can be used to store fluids that counteract corrosion. On wells that make gas, compartments can be filled with oil to reduce friction and heat. This equipment is made to attach to almost any kind of stuffing box. *O. G. Pro Technical Service Co.*

Circle number (6) on reply card.

New Triplex Plunger Pump. Gaso Pump & Burner Mfg. Co. has added a new 2½ in. to 3½ in. by 4 in. Horizontal Triplex Plunger Pump, fig. 3466. Unit is a high-speed, single-acting pump for use where moderate capacities and medium to high pressures are required for crude oil gathering systems, movement of refined petroleum products, salt water disposal, water flooding and fresh water supply. Maximum speed is 250 rpm. *Gaso Pump & Burner Manufacturing Company.*

Circle number (7) on reply card.

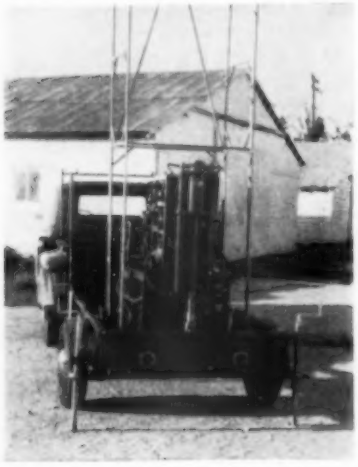
New Engines. Two new engines, the D318 and D315 Series G engines, are offered either naturally aspirated or with turbocharger. Designed for special applications where space and weight are important factors, the 2 engines are smaller and lighter than their standard counterparts. Several major modifications were



made to reduce the over-all length and weight of the engines. A new timing gear and housing require only half as much length as before. A compact air cleaner of increased efficiency has been placed in a new position to give a shorter, lower engine profile. The former gasoline starting engine is replaced by a 24-v direct electric starting system. The D318 Series G engine has an over-all length of about 56 in. and develops 137 hp at 2000 rpm. Turbocharging increases this rating to 175 hp. D315 Series G engine develops 91.5 hp naturally aspirated. *Caterpillar Tractor Company.*

Circle number (8) on reply card.

Core Drill. ADCO 1000 hydraulic core drill, with 4-speed transmission, is a portable unit for shallow oil or mineral exploration, water well and soil test drilling. Drill is powered with a 2-cylinder TFD 14-hp Wisconsin engine for drilling



to 1000 ft, or may be used with a 30-hp engine for drilling to 3500-ft depths. Drilling up to 3-in. diameter holes with diamond core, insert or roller type bits, 15/16 in. standard "E" rod is used. *Allied Drilling Company.*

Circle number (9) on reply card.

Self-priming Lightweight Pump. Worthington announces a new self-priming, self-lubricating centrifugal pump that is lightweight and resists corrosion. Available in three ratings—½, ¾, and 1 hp—with dual discharge openings for flexibility in piping. Solid aluminum casing, head and impeller makes the pump extremely lightweight (¾-hp unit complete with motor weighs only 62 lb. Pump is the first size of new line of self-priming pumps. Motor and engine driven units will be available up to 6 in. pipe size. *Worthington Corporation.*

Circle number (10) on reply card.

Protective Coating. Maintz, a new coating designed to provide protection of equipment against chemical and weather exposure, has been introduced to the petroleum industry. Based on Du Pont's chlorosulfonate polyethylene and a combination of silicone and other resins, material is inert chemically and dries to a tough, resilient coating. *West Chester Chemical Company.*

Circle number (11) on reply card.

Multipurpose Shothole Rig. A new, high-powered mobile rotary drill, the B-52 "Pacemaker," handles auger boring, core and percussion drilling and soil sampling tasks with equal speed and versatility. A traveling laboratory, the Pacemaker can stay in the field almost indefinitely. It is equipped with cabinets for soil sampling equipment, plus racks for extra augers, drill stems and other tools. Self-powered, it can generate up to 5 tons push or pull ram force. The unit handles 6-ft sectional augers in sizes from 3 to 24 in. and drives a full 6-ft stroke. It bores to 150 ft in unconsolidated materials, to 600 ft with N rods and 1000 ft with A rods. *Mobile Drilling, Inc.*

Circle number (12) on reply card.

Resistivity-Caliper Log in One Tool. Combining two instruments in one unit, PGAC's Micro-Caliper Log simultaneously and automatically records the resistivity of a minute volume of material close to the wall of the hole and measures the diameter of the hole. Tool employs a special hydraulic logging pad and a back-up pad which are held firmly against the walls of the hole under uniform pressure. A series of electrodes are mounted in the logging pad with a short space between the electrodes.

Calipering device is mechanically connected to both the hydraulic and the back-up pads, standard Micro-Caliper tools can be used in hole diameters ranging from 5½ to 16 in. In operation, tool is lowered into the hole with its logging pads in a contracted or collapsed position. Arms carrying the logging pads are released when on bottom by means of a small powder charge which is fired by remote control from the logging truck. *Perforating Guns Atlas Corporation.*

Circle number (13) on reply card.

Relief Valves. Pressure relief valves, Models 412 and 414, meet need for a simple and accurate, yet safe and dependable means of relieving excessive pressures at strategic points in pressure systems. Line pressure is utilized for opening and closing valves with opening pressure preset by application of dead weight or spring load. Designed for instantaneous opening to full capacity, valves can be functionally tested at any pressure by hand lifting the pilot stem which operates them; opening pressure can be set accurately without flowing main valve. These valves are suitable for operation at temperatures up to 300 F. *Kinzbach Tool Company.*

Circle number (14) on reply card.

Coated Ball. A new coated perforation ball sealer for use in fracture and acidizing operations has been developed by Dowell Incorporated. Ball consists of a hard nylon core which prevents extreme distortion and reduces possibility of pump-through, and a soft vulcanized Neoprene coating to provide good sealing characteristics in irregular perforations. Tests indicate good sealing with 5000 psi at 300 F. Following tests no sticking is encountered. *Dowell Incorporated.*

Circle number (15) on reply card.

Small Desanding Unit. Size 2 Dorrco D-Sander, designed especially for hard formation drilling, features low first cost and operating cost, light weight and portability. Manufactured by Dorr-Oliver and sold by Salt Water Control, the D-Sander has a capacity up to 250 gal a minute. It compliments the capacity ranges of the Size 4 and Size 6 which have capacities up to 500 and 800 gal a minute, respectively. *Salt Water Control Inc.*

Circle number (16) on reply card.

MEN OF FORESIGHT READ NEW EQUIPMENT

MEN OF PROGRESS READ ADVERTISEMENTS

MEN OF ACTION USE READER SERVICE CARDS

Selective Signaling Package. A single-unit console providing complete selective calling facilities for land-mobile 2-way radio base station installations is announced by Motorola. New console combines all tone signaling elements, including tone generator, timer, power supply and code selector, in a single compact package. Greatly simplified with respect to installation, adjustment and operation, the console can be quickly and easily added to any existing 2-way radio system. *Motorola Inc., Communications & Industrial Electronics Division.*

Circle number (17) on reply card.

Mobile Radiotelephone for Field Work. Mobile AM radiotelephone, designed to provide reliable long distance communications under adverse terrain conditions, was specifically developed to handle field communications in oil exploration, mining, foreign construction, pipelines, geological survey, and governmental agencies. *Kaar Engineering Corp.*

Circle number (18) on reply card.

Transmission. Motor truck division of International Harvester introduces a new Select-O-Matic transmission for heavy-duty International trucks. Select-O-Matic features an electro-hydraulic clutch and high-efficiency torque converter in combination with a 5-speed synchromesh transmission. The electro-hydraulic clutch is disengaged for shifting by a button located under the gear shift knob. *International Harvester Company.*

Circle number (19) on reply card.

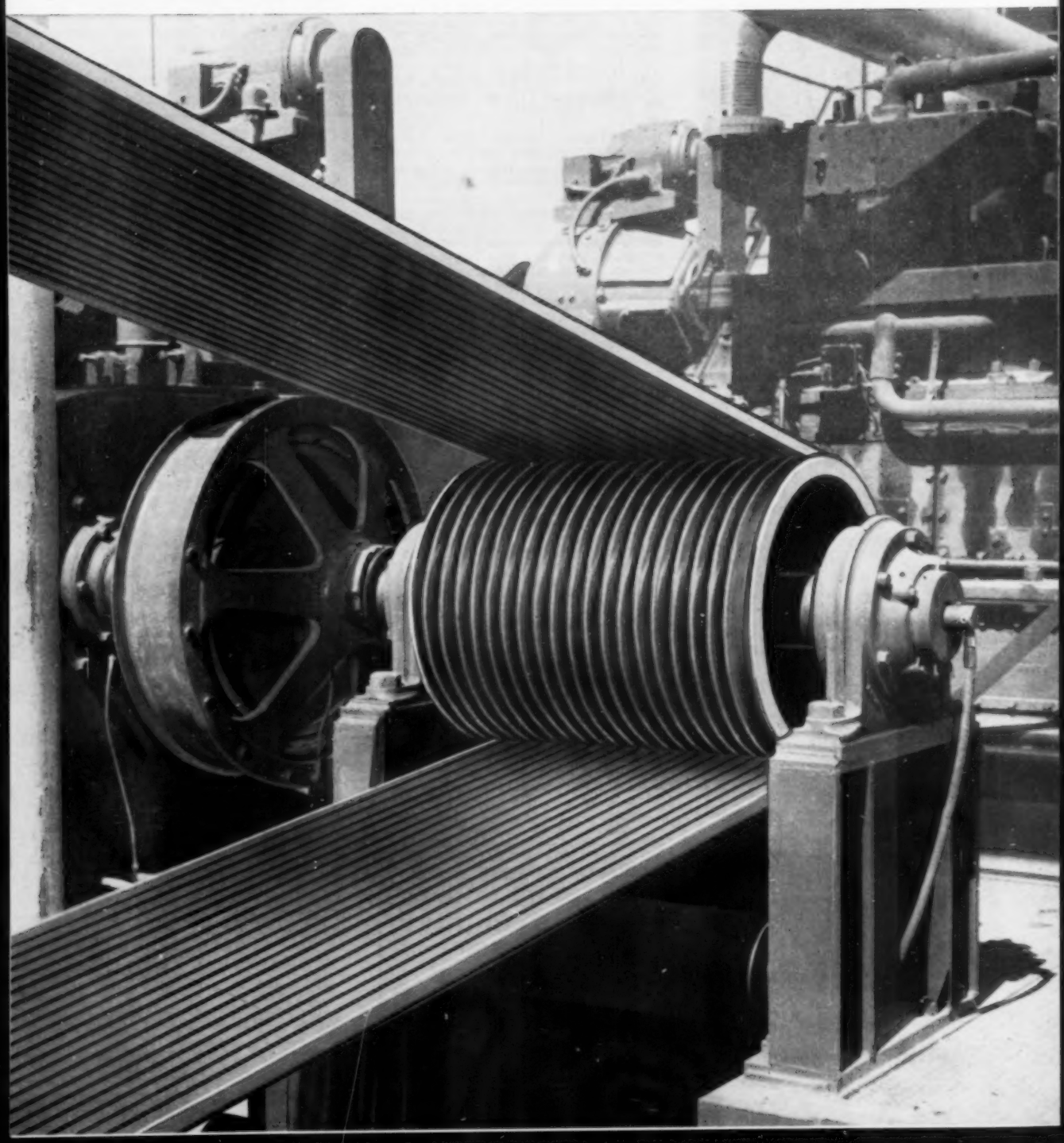
Cementing Turbulence Unit. Where movement of casing during the cementing operation is not practical, an installation of B and W Multi-Flex clusters, spaced at the top and bottom of productive sections, may be used to assist in providing effective cement seals. Turbulence and agitation of gelled mud in the enlarged shale sections tend to create an improved condition for cement placement as the B and W Multi-Flex clusters are run. *B and W Inc.*

Circle number (20) on reply card .

Junk Mills. New tool has been designed to mill junk inside the casing, drill complete bits which have been lost in the hole, and for clean-out work. Similar to Servco CA Whipstock Mills, Servco Junk Mills are available in sizes from 3¾ to 11 in. OD. *Servco Corporation.*

Circle number (21) on reply card.

WHY MULTI-MATCHED MAKE YOUR MAINTENANCE DOLLAR



DAYTON V-BELTS STRETCH FARTHER

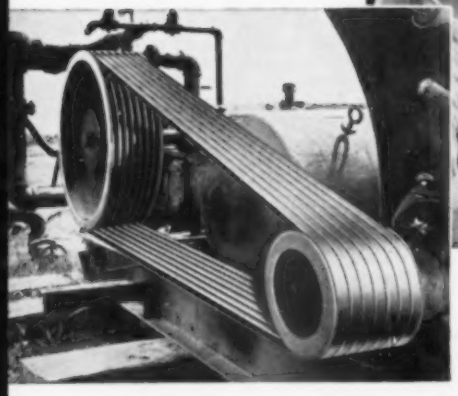
Precision matching assures long, uniform life for every V-Belt in a set

In transmitting power to mud pumps and draw works the service life of the *set* is the important thing. Premature failure of one or two V-Belts in a set is costly. And only when a set is accurately matched can it give the long trouble-free performance that makes your rig maintenance dollars cover more ground.

To be certain you get the longest possible service, Dayton *multi-matches* every set. Strict quality controls make every V-Belt as alike as possible in construction. Then they are matched in the factory on precision machines. Again and again at Regional and District Warehouses matching is checked and re-checked. Always the same type of precision equipment is used.

These matching machines, called Matchometers, are designed and built exclusively for Dayton. Their repeated use is your assurance that each Dayton V-Belt in a set will pull its share of the load.

Next time you order, remember *multi-matched* Dayton V-Belts. You can get them at any of the supply points shown at right.



Every set of Dayton Thorobred V-Belts is *Multi-Matched* on precision Matchometers, the finest device made for matching V-Belts, built exclusively for Dayton Rubber Company.

© D.R. 1957

World's Largest Manufacturer of V-Belts

Dayton Rubber

The Dayton Rubber Company, Industrial Replacement Div., Dayton 1, Ohio

Dayton V-Belts Available Through over a Hundred Oil Field Supply Points

DAYTON REGIONAL WAREHOUSES

Los Angeles, Calif.—909 East Slauson
Dallas, Texas—925 Slocum
Houston, Texas—1308 La Branch

DAYTON DISTRICT WAREHOUSES

California
Bakersfield—109 23rd St.
San Francisco—401 Howard St.

Louisiana
Morgan City—Highway 90
New Orleans—632 S. Peters St.
Shreveport—214 N. Market St.

Texas
Abilene—628-30 Walnut St.
Corpus Christi—1920 N. Port Ave.
El Paso—1701 Texas St.
Odessa—111 N. Lee St.
Pampa—159 S. Cuyler St.
Wichita Falls—1300 Indiana Ave.

FIELD STORE STOCKS

Arkansas
All Republic Supply Stores

California
All Bethlehem Supply Stores
Bakersfield—Power Transmission and Equipment Co.
San Francisco—H. N. Cook Belting Co.

Colorado
All Republic Supply Stores

Illinois
All Republic Supply Stores

Kansas
All Republic Supply Stores
Coffeyville—Acme Foundry Co.

Louisiana
All Republic Supply Stores
Lake Charles—
Behring's Bearing Service of La., Inc.
Morgan City—Morgan City Supply Co.
New Orleans—
New Orleans Belting and Bearing Co.
Oil City—Oil City Hardware Co.
Shreveport—Bearing Transmission Co.

Nebraska
All Republic Supply Stores

New Mexico
All Republic Supply Stores

Oklahoma
All Republic Supply Stores
Oklahoma City—Green Head Service Co.

Texas
All Republic Supply Stores
Abilene—Carpenter V-Belt Co.
Amarillo—Radcliff Supply Co.
Beaumont—Behring's, Inc.
Borger—Radcliff Supply Co.
Brownsville—Alamo Iron Works
Cisco—Walton Electric Co.
Corpus Christi—Alamo Iron Works
Bradley's Motor & Armature Works
Houston-Oil Field Material Co.
Stewart Dean Co.
El Paso—El Paso Saw & Belting Co.
Freer—Houston-Oil Field Material Co.
Houston—
Behring's Bearing Service Co.
Houston-Oil Field Material Co.
Kilgore—Jack Anderson Engine Co.
Lubbock—Lubbock Electric Co.
Bearing Specialists Co.
Lufkin—Lufkin Foundry & Machine Co.
Midland—Electric Motor Service Co.
Odessa—Duke Electric Co.
Pampa—Radcliff Supply Co.
Pearsall—Houston-Oil Field Material Co.
San Antonio—Alamo Iron Works
Wichita Falls—Mims Bearing Co.
Hornsby Heavy Hardware Co.

Wyoming
All Republic Supply Stores

NEW Literature

For more information on items described here in brief, use the handy reply card and circle the corresponding numbers

Wire Rope. By means of photographs and drawings with reeving diagrams, a new brochure lists the proper wire rope specification for all types of construction equipment. Included is a discussion of Lang Lay vs. Regular Lay rope, rope constructions and proper wire rope to use for clamshell bucket operation. Called "The Correct Wire Rope for Contractors' Equipment," brochure is No. 5702. *Macwhyte Company.*

Circle number (22) on reply card.

General Catalog. McCullough Tool Company has issued a 40-page, illustrated general catalog. It contains a complete description of the entire line of specialized tools and services available to the oil industry through the company. Included are the most recent improvements in such tools as M-3 bullet perforators, chemical tubing cutter, "Carrot-free" glass jet perforators, Type "B" drillable bridge plug, magnetic collar locator, sonic device and sonic collar locator. *McCullough Tool Company.*

Circle number (23) on reply card.

Revised Condensed Catalog. A completely revised condensed 28-page catalog (C-5000, Rev. 8) covering Rockwell meters, regulators, and valves has been introduced by Rockwell Manufacturing Company. Outstanding new features of the catalog include photo-illustrated descriptions of the recently introduced Rockwell telapilot—with power pilot loading by remote control—and the Hypregun, a light, compact, efficient air-operating valve lubricant gun. *Rockwell Manufacturing Company.*

Circle number (24) on reply card.

Bronze and Steel Valve Catalog. New 80-page catalog on "Hancock" bronze and steel valves has been produced by Manning, Maxwell & Moore, Inc. Designs include globe, angle, gate, "Flocontrol" and other types applicable to power, petroleum, chemical and general industry installations. *Manning, Maxwell & Moore, Inc.*

Circle number (25) on reply card.

Gas Drilling Engine. Bulletin 103 features the Model 6G-510 Superior gas drilling engine developed by White Diesel Engine Division of the White Motor Company. Power for all oilfield jobs, the 4-cycle, 6-cylinder engine is distinguished by simplicity of design and heavy duty construction. Bulletin shows specifications, dimensions, performance curves. *White Diesel Engine Division.*

Circle number (26) on reply card.

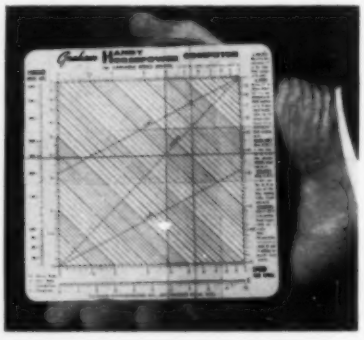
LXS Chain Book. Book No. 2454 by the Link-Belt Company contains a complete presentation of the features of LXS bushed roller chain. Manufactured in 2 designs, straight or offset sidebars, the chains are supplied with small or large rollers to cover a wide variety of power transmission or conveyor applications. Nineteen sizes of offset sidebar chains for power transmission applications are available, ranging in pitch from 1.5 to 5 in. with ultimate strength ranges from 8,000 to 280,000 lb. *Link Belt Company.*

Circle number (27) on reply card.

Traveling Blocks. National Supply travelling blocks of 5 capacities which cover all oilfield drilling requirements ranging from 90 to 450 tons are described in Bulletin No. 471. Features of design and construction are presented. *The National Supply Company.*

Circle number (28) on reply card.

Fascinating Numbers. The Graham Computer and booklet "Fascination in Numbers" is offered to readers by Graham Transmissions Inc. A unique computer, it can be applied to ordinary slide rule



calculations as well as special business problems. Designed for horsepower calculation, the calculator has been used in calculating the volume of tanks. For instance, for a formula for capacity of a tank in gallons in terms of tank diameter and length, the special vertical scale for diameter at the left would have markings on each side and would include the diameter square and the constant, and the standard horizontal scale at the bottom would set the length — the capacity being read on the diagonal. *Graham Transmissions, Inc.*

Circle number (29) on reply card.

Widening Uses of Microfilm. The widening scope of microfilm as an everyday office, engineering department and record room work tool for active paperwork is detailed in a new 4-color, 36-page brochure issued by the Filmsort Division of Dexter Folder Co. Titled "New Horizons With Microfilm," the booklet describes the conception and growth of the Filmsort system for activating microfilm by mounting it in aperture cards or jackets; gives details of new equipment, supplies and techniques for handling engineering drawings, personnel and other office records, traffic control material, etc., and provides several pages of case history reports. *Filmsort Division of Dexter Folder Co.*

Circle number (30) on reply card.

Wire Rope Bulletins. "Rope Dope" has become the familiar title of a series of educational bulletins published by Union Wire Rope Corporation. In Volume No. 5 of Rope Dope Educational Bulletins, now off the press, the accumulation of recommended practices have been reorganized and are carried in more normal sequence through 7 different bulletins. Much new information has been included. *Union Wire Rope Corporation.*

Circle number (31) on reply card.

Rotary Drill Rig. Extreme portability and speed of the Model 35 rotary drill rig are explained in a new bulletin issued by Joy Manufacturing Company. Bulletin features field photographs and complete specifications illustrating the flexibility of the Joy "Thirty-Five" as a geophysical shot hole or shallow water well rig. *Joy Manufacturing Company.*

Circle number (32) on reply card.

Cushioned Float Valves. A new 16-page technical bulletin explaining the features of Golden-Anderson cushioned float has been published. G-A cushioned float valves maintain accurate water level control in elevated tanks, reservoirs, coagulating basins, mixing chambers, etc. *Golden-Anderson Valve Specialty Co.*

Circle number (33) on reply card.

"How to Buy a Used Machine Tool." A new booklet on "How to Buy a Used Machine Tool" has been published by S & S Machinery Company. Written in question and answer form, it covers most aspects of used machinery purchase, with the answers given by Louis D. Srybnik, S & S vice president. *S & S Machinery Company.*

Circle number (34) on reply card.

Wire Rope Slings. Three new folders describing suggested applications and ordering specifications for wire rope slings have been made available by the Wickwire Spencer Steel Division of The Colorado Fuel and Iron Corporation. Folders describe Wickwire's Uniflex wire rope slings, Multiflex wire rope slings, and Maxiflex wire rope slings. Each folder describes specific applications for which each sling is best suited, with illustrations of typical applications. *The Colorado Fuel and Iron Corporation.*

Circle number (35) on reply card.

Motion Pictures. Catalog describing educational and entertaining motion pictures sponsored and distributed by United States Steel includes 5 new films released in 1956. Films are available to all recognized groups without cost. Booklet lists more than 18 films available for showing. *United States Steel Corporation.*

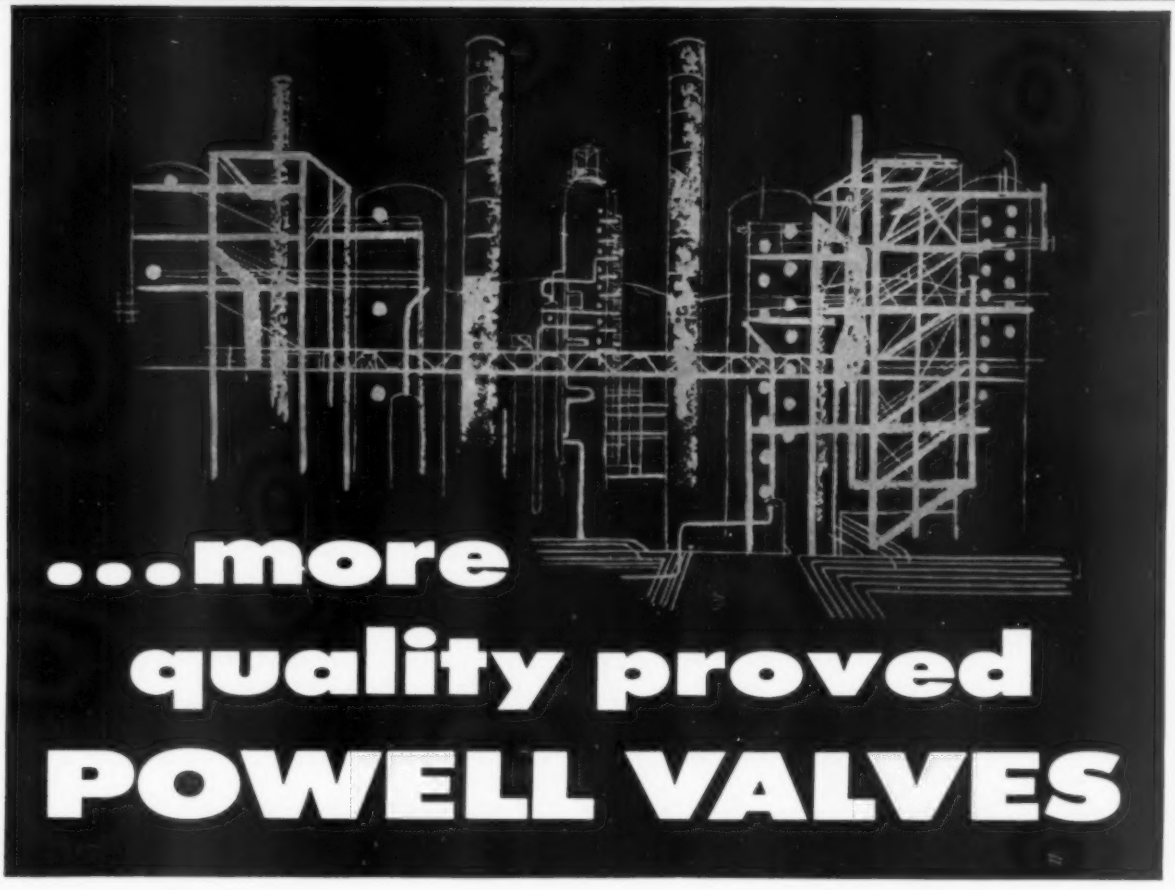
Circle number (36) on reply card.

Floodlighting Catalog. An illustrated catalog by Stonco Electric Products Company condenses their cast aluminum floodlighting line into 48 pages. Cast aluminum vaportight pendant, ceiling and wall fixtures, wiring troughs, splice boxes and other outdoor fittings, and sealed-beam floodlighting lampholders are listed. Complete lighting performance tables are included for the new high efficiency long-throw. *Stonco Electric Products Company.*

Circle number (37) on reply card.

Oilfield Engines. Horsepower rating data on Allis-Chalmers oilfield engines is available in a new 4-page bulletin, BU 165. Data covers 16 natural gas powered models, 15 powered by either butane or propane gas; 17 diesel engines, and 14 engines powered with gasoline. *Allis-Chalmers Manufacturing Company.*

Circle number (38) on reply card.



...more quality proved POWELL VALVES

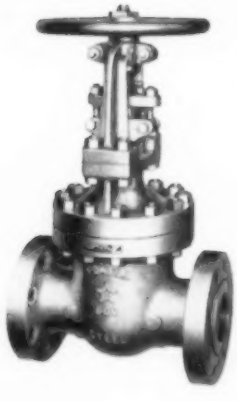
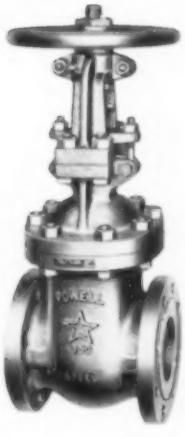


FIG. 6003 SS - Alloy Steel Gate Valve for 600 Pounds W.S.P.

FIG. 3061 - 300-Pound Steel Swing Check Valve.

FIG. 1563G - Gear Operated Lubricated Plug Valve, 150 Pound Steel.

FIG. 1503 - 150-Pound Steel Gate Valve.



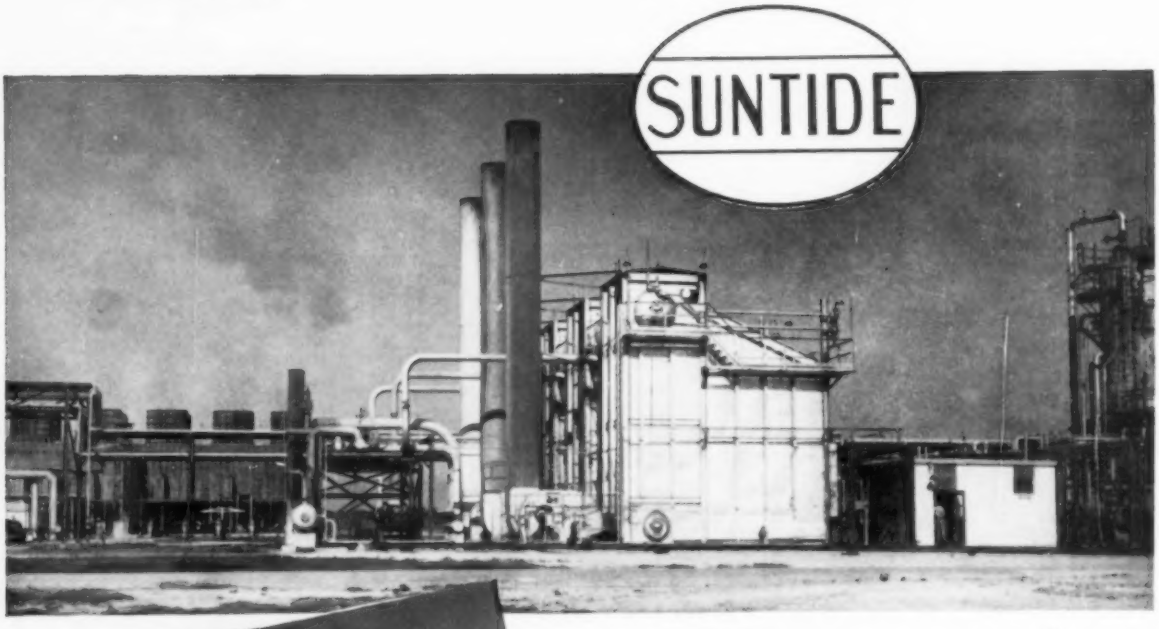
Designed for long life, designed for dependable service

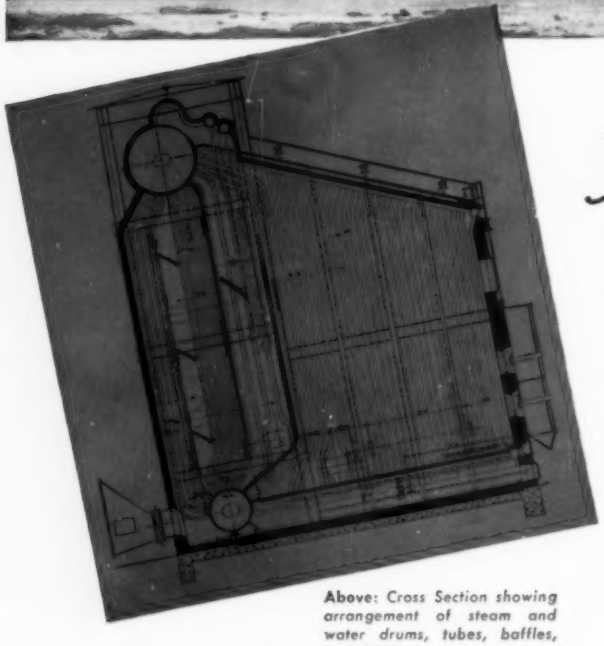
Consult your Powell Valve distributor for all the facts about quality proved bronze, iron, steel and corrosion-resistant valves. For every flow problem . . . there is a Powell Valve to solve it.

THE WM. POWELL COMPANY, CINCINNATI 22, OHIO . . . 111th YEAR

Vogt STEAM GENERATORS

at **SUNTIDE REFINING COMPANY**
Viola, Texas





Above: *Cross Section showing arrangement of steam and water drums, tubes, baffles, and furnace.*

3 Units Installed
2 Units on Order

Principle Data Each Unit

- 85,000 pounds steam per hour capacity, designed for 500 lbs. S.W.P. and 625° F. total temperature.
- Water cooled furnace.
- Burners for Gas and Oil fuel.

Vogt offers a complete line of custom built and package type steam generators. Available in bent tube and straight tube designs for solid, liquid, or gaseous fuels burned singly or in combination.

Write for bulletins. Dept. 24A-BRE

OTHER VOGT PRODUCTS

Drop Forged Steel Valves, Fittings and Flanges—
Petroleum Refinery and Chemical Plant Equipment
Heat Exchangers
Ice Making and Refrigerating Equipment

HENRY VOGT MACHINE CO.
Box 1918, Louisville 1, Kentucky

SALES OFFICES: New York, Chicago, Cleveland, Dallas, Philadelphia, St. Louis, Charleston, W. Va., Cincinnati

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

New Projects in refining gas processing petrochemicals

British-American Oil Company signs a $4 million contract with Fluor Corporation for offsite building at its Clarkson, Ontario, plant. This raises Fluor's quota to $7 million-plus.

Utah Oil Refining Company will spend $4.2 million for expansion, the major part for a carbon monoxide boiler, etc., at Salt Lake City plant.

Goodrich-Gulf Chemicals will spend $2 million to convert the Institute West Virginia plant to make 50,000 tons of Ameripol (cold) rubber annually.

El Paso Natural Gas Products Company plans a 6500 BPD refinery near Odessa, Texas. Tied in with its nearby synthetic rubber units, refinery will get 2000 BPD of unsaturated by-products, styrene, butenes, etc. from that plant. Refinery includes crude unit, alkylation (HF), cat cracking and reforming units, gas concentration plant. UOP is doing process design, Fish Engineering the procuring and engineering work.

Esso Standard Oil Company, modernizing its Bayonne plant, first will construct new central warehouse and mechanical shop facilities.

Alaska-Yukon Refiners & Distributors will build the first Alaskan refinery at Haines, S. E. panhandle, of 7500 BPD, it is to start operations in 1958.

Ethyl Corporation is to build a TEL plant at Pittsburg, California, for supplying the West Coast. Engineering is by C. F. Braun Company, to be operating by mid-1958.

Douglas Oil Company is expanding its Bakersfield, California refinery, $1.2 million worth; plans 12,000 BPD crude unit, 10 percent more thermal cracking capacity, building a 1500 BPD Unifiner.

Phillips Petroleum Company contracts with Fluor Corporation, Ltd., for a 16,000 BPD low endpoint cat reformer and desulfurizer, at Sweeny, Texas, to be completed in January.

Western Germany is the scene of heavy construction, such as:

- Esso plans a big Cologne refinery; is expanding its Hamburg plant.
- Shell plans a 60,000 BPD plant between Bonn and Cologne, expandable to 140,000 BPD; will increase Hamburg plant from 16,000 to 56,000 BPD.
- Petrofina will build 60,000 BPD plant at Duisburg, Ruhr.
- British Petroleum subsidiary plans an 85,000 BPD plant near Cologne, to be upped later to 120,000 BPD.
- Scolven-Chemie A. G. will boost its Buer plant to 40,000 BPD.

Construction Notes in Brief . . .

Construction Contractor	Engineering and Design Company	Location	Type of Plant or Unit	Rated Capacity	Cost	Schedule for Completion
		Bankline Oil Company				
—	D. Reynolds	Bakersfield, Cal.	Catalytic Reformer	4000 BPD	$1,000,000	Sept. 1957
—	D. Reynolds	"	Hydrodesulfurization	4000 BPD	—	"
Fluor Corp., Ltd.	Same and Esso	"	Fluid Coker	4000 BPD	—	Dec. 1957
Staff	Staff	"	Alkylation Unit Revamp	800 BPD	$500,000	—
		Consumers Cooperative Refinery Association				
S'western Eng. Co.	Same and UOP	Phillipsburg, Kansas	Platformer	3500 BPD	—	—
"	"	"	Unifiner	3500 BPD	—	—
		Esso Standard Oil Company				
Staff	Staff & Esso Research	Linden, N. J.	Lt. Virgin Naphtha Hydrofiner	15,000 BPD	—	—
		Farmers Union Central Exchange, Inc.				
—	—	Laurel, Mont.	Refinery Modernization	17,000 BPD		—
—	—	"	Unifiner	7000 BPD	$3,000,000	—
—	—	"	Platformer	4500 BPD		—
		Hancock Oil Company				
Ralph M. Parsons Co.	Same	Signal Hill, Cal.	Crude Capacity	7000 BPD	—	—
"	"		Visbreakers	3450 BPD	—	—
"	"		Cat Cracker	2100 BPD	—	—
"	"		Fluid Coker	6000 BPD	$2,000,000	Mid 1957
		Imperial Oil Company, Ltd.				
—	—	Ioco, B. C., Canada	Powerformer-Hydrofiner	5800 BPD	$4,000,000	Dec. 1957
		Kerr-McGee Oil Industries, Inc.				
—	—	Wynnewood, Okla.	Platformer	5500 BPD	—	—
—	—	"	Unifiner	4000 BPD	—	—
		Rothschild Oil Company				
C. F. Braun & Co.	—	Santa Fe Springs, Calif.	Cat Cracking	8000 BPD	$2,000,000	—
		Shell Oil Company of Canada				
Refinery Eng. Ltd.	Same, Shell & UOP	Montreal, E., P. Q. Canada	HF Alkylation	1500 BPD	—	—
		Standard Oil Company of Ohio				
M. W. Kellogg Co.	Same and Sohio	Toledo, Ohio	Expand Refinery	60,000 BPD	$32,000,000	April 1958
		The Texas Company				
Bechtel Corp. and Chicago Br. & Iron Co.	—	Anacortes, Wash.	Crude Capacity	40,000 BPD	—	Jan. 1959
"	—	"	Cat Cracking	18,000 BPD	—	"
"	—	"	Platformer	7000 BPD	—	"
		Tidewater Oil Comapny				
Bechtel Corp.	Same and Houdry	Avon, Calif.	Houdriformer	22,500 BPD	—	March 1958
		Union Oil Company of California				
C. F. Braun & Co.	Same and UOP	Wilmington, Calif.	Platformer	14,500 BPD	$12,000,000	—
"	"	"	Unifiner	15,750 BPD	—	—

Tracing the path of fuel with carbon-14

Ethyl Research tags 1 in 100,000,000 atoms with radioactive carbon for a better picture of distribution in the cylinders.

by D. E. COOPER

Ethyl Corporation, Detroit, Mich.

The distribution of fuel components and fuel additives to the cylinders of multicylinder engines is of prime importance to the petroleum industry. Just as a chain is only as strong as its weakest link, so is an engine's performance limited by the one cylinder which does not continuously get its proper dosage of high-octane hydrocarbons or of tetraethyllead.

The goal of engine designers is the creation of an engine wherein the fuel/air ratio, hydrocarbon composition and additive concentrations are identical for each cylinder of a multicylinder engine. Fuel injection—now becoming commercially available—represents one approach to the solution of this difficult problem.

Whether fuel injection or carburetion is employed, however, an accurate knowledge of fuel and additive distribution in engines is necessary to assure optimum use of the gasolines the refiner is producing today.

A continuing study

As is the case with most of Ethyl's other basic research studies, the study of fuel distribution has been a continuing one. Some years ago, a glass manifold was installed on an engine and motion pictures were made of flow patterns, giving some insight into the quantities of fuel mixture fed to various cylinders.

A second step in Ethyl fuel distribution studies involved the tagging of specific hydrocarbons with deuterium or heavy hydrogen. One component (the cyclopentanes, for example) had a specific number of hydrogen atoms replaced with heavy hydrogen. This special fuel was then burned in the engine. Samples of the exhaust gases from various cylinders were condensed and analyzed in a mass spectrometer to give a picture of the distribution of that particular

FIGURE 1. Nose view of combined sampling valve and spark plug.

FIGURE 2. Test engine in the laboratory and gas sampling and collecting system.

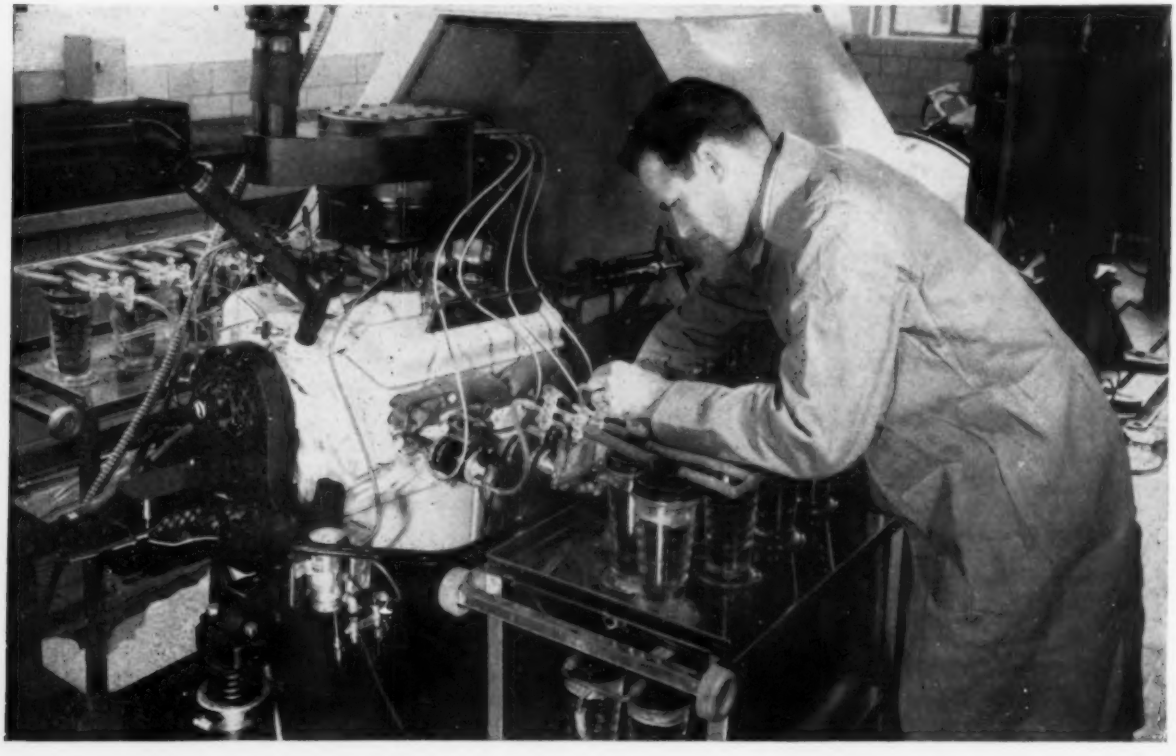


FIGURE 3. Scintillation counter setup at Ethyl Research Laboratories for examining tritium-containing condensate samples.

hydrocarbon among the cylinders of the engine on test. This technique required, however, that the ratio of heavy hydrogen to normal hydrogen be at least 1 to 100 and thus ruled out studies of additive concentrations, which are much smaller.

Tagged carbon atoms

A third step in this continuing program of fuel distribution studies has involved switching from a stable isotope such as deuterium to a radioactive one such as carbon-14. Now it becomes possible to tag tetraethyllead with carbon-14 and measure its concentration in an engine cylinder accurately, even though only one tagged atom is present among 100,000,000 normal carbon-12 atoms!

All of these distribution studies involved the use of a quick-opening (1/1,000 second) sampling valve. This valve samples the contents of a particular cylinder. It is screwed into the spark-plug opening and combines the sampling valve with spark-plug electrodes. Figure 1 shows a nose view of this combined sampling valve and spark plug.

Figure 2 shows the test engine in the laboratory and the gas sampling and collecting system. The gas samples are bubbled through absorbing solutions of barium hydroxide. The carbon dioxide is regenerated and transferred to an ionization chamber, where its beta activity is measured by a vibrating-reed electrometer.

And now . . . tritium

The newest refinement in this study consists of the replacement of carbon-14 with hydrogen-3 or tritium as the radioactive tracer element. The use of tritium simplifies and makes less expensive the preparation of tagged hydrocarbon or additive molecules for study. It also simplifies the exhaust-gas-sample collection technique. The scintillation counter used for studying the tritium-containing condensate samples from the cylinders is shown in Figure 3.

As is the case with all of our basic research studies, the information from this continuing study of fuel distribution is available to the petroleum industry. We would be happy to discuss any particular aspect of this problem with you in your office. We would also be happy to have you visit our Detroit Laboratories to see this equipment and discuss it with our technical personnel. In either case, contact your local Ethyl representative for an appointment.

What Ethyl Research offers you

Ethyl Research is in the unique position of serving both the petroleum and automotive industries.

In that capacity, we have contributed much in the field of fundamental as well as applied research. Today at our laboratories in Detroit we are conducting studies on the distribution of fuel components and fuel additives to the cylinders of multicylinder engines.

Searching for answers to these basic problems has led us to develop many new instruments and new techniques. The information which we have developed from our research efforts is being constantly circulated throughout both the automotive and petroleum industries to help them with their research.

If you desire any information concerning fuel-engine problems, just contact your Ethyl representative.

ETHYL
ANTIKNOCK COMPOUND
ETHYL CORPORATION

ETHYL CORPORATION
New York 17, N. Y.

The ultramodern refinery of The Texas Company at Westville, N. J., across the river from Philadelphia.

Map of the Philadelphia area, showing refinery sites, waterways, ship and barge routes, and pipelines.

Economics of Oil Refining

In The Philadelphia Area

John J. Schanz, Jr.
Assistant Professor of Mineral Economics
and Robert C. Barwick
Chief, Division of Minerals, Pennsylvania State University; Department of Forest and Waters, Commonwealth of Pennsylvania

Factors of water, pipeline, rail and truck transport, access to ocean routes, and central location in a huge consuming area make this one of the largest refining centers

PENNSYLVANIA occupies a significant position in the American petroleum industry because of three factors. The first oil well in the United States was drilled in Pennsylvania. Second, "Pennsylvania Grade" crude oil has provided lubricants which have always commanded a premium price. Third, although only sixteenth in crude production, the state is fourth in petroleum refining capacity.

The early history of American oil and the unique position of the Penn Grade refiner is the result of operations in the western part of Pennsylvania. The importance of the state in refining today, however, is due to the presence of large refineries processing foreign and Gulf Coast crude in the lower Delaware River valley near Philadelphia. A study of the operations in this area reveals the fundamental economics of refineries located in the marketing area.

The first refining of petroleum in Pennsylvania was done in 1855 by Sam Kier who hoped to produce an illuminating fuel in addition to Seneca Oil Medecine. However, refining could not develop until it was discovered that a kerosine fraction could be separated from crude oil by distillation. This discovery was followed by the rapid development of a large number of simple distillation plants throughout western Pennsylvania.

With the turn of the century, the growth in demand for a variety of petroleum products, particularly gasoline, and the decline in the output of Pennsylvania Grade crude made it necessary for the northeastern states to turn to imported crude or products. This led to both a large volume of tanker shipments of crude and products to the East Coast as well as the construction of refineries along the seaboard. The Philadelphia area became the most important of these eastern tidewater refinery centers.

Location of Refineries

Without exception, the refineries of the Philadelphia area are located on a river or bay suitable for ocean tanker navigation. Being dependent upon crude oil from the Gulf or from foreign sources, this type of location is essential. There are six large operating re-

fineries and one under construction in this area, all situated along a 30-mile stretch of the lower Delaware River. See map and Table 1 for list of refineries included.

Refinery Operation

All of the refineries in the Philadelphia area are part of completely integrated petroleum companies. That is, the companies engage in production, transportation, refining, and marketing activities. The refineries are among the largest in the world and employ from 1500 to 4000 men. In addition to refining itself, these large refineries require the construction and operation of many so-called "off-site" facilities that are not a direct part of the refining of the crude. The off-site activities include construction of process equipment, construction of oil movement equipment, construction of storage facilities, construction of roads, manufacture of cans, manufacture of additives, research, and development.

The total refining capacity of the Philadelphia area as of January 1, 1956, was 738,000 bbl of crude oil per day.* This capacity will be increased by 130,000 bbl per day when the Tidewater refinery is completed in late 1956 at Delaware City. The refineries in the area during 1956 were utilizing more than 60 per cent of their capacity to process crude oil from Latin America and the Middle East. The remainder of the crude was shipped in from the Gulf Coast. Each of the six major companies in the area is engaged in production at overseas sites. The imported crude is usually processed as a blend with the domestic oils used. This area is one of the focal points for importation of crude as shown by the fact that 86 per cent of all East Coast crude imports in July, 1956, arrived in either Pennsylvania or New Jersey. The lower delivered price of Middle East crude to the Philadelphia area has certainly been an important factor in the development of this situation. (See Table 3.)

Economic Aspects

The large metropolitan marketing area surrounding Philadelphia, plus its access to the sea, is an ideal location for a refinery. All crude is delivered to the area by ocean-going tanker, the lowest cost method available. Though the sources of crude are thousands of miles away, the comparative cost of tanker shipment is so low that crude can be shipped economically into the area. Refined products, on the other hand, that must travel by more expensive methods have to be moved only comparatively short distances.

The refineries in the Philadelphia area are among the largest and most costly in the United States. The average size is 123,000 bbl per day of crude oil capacity. For this size refinery, producing the full range of products, the cost of installation is of the order of $1000 for each barrel of daily capacity. The range in size in the Philadelphia area is from 60,000 bbl to 183,000 bbl per day.

Though the total cost of a large refinery is of much greater magnitude than that of a small refinery, the cost per barrel of capacity is appreciably lower. The small refinery requires the same expensive equipment as does the large, but the cost of the equipment does not increase in proportion to the increase in size. Consequently, a large refinery is actually more economical to build than a small one on a per-barrel basis.

A refinery must operate at, or near, capacity because of the large proportion of fixed costs. If it operates much below capacity the charge against each barrel of output to cover the fixed costs will then become uneconomical. It is typical for a refinery to operate at approximately 95 per cent of rated capacity when averaged over a period of 25 years.

Therefore, if a refinery is to take advantage of the lower cost per barrel of capacity in a large installation, there must be a market area large enough to absorb the output. The Philadelphia area offers such a market for large capacity refineries. Not only is the market large and concentrated in area, but it is also near good harbor facilities for water transportation. It has proved to be a natural location for maximum refinery size.

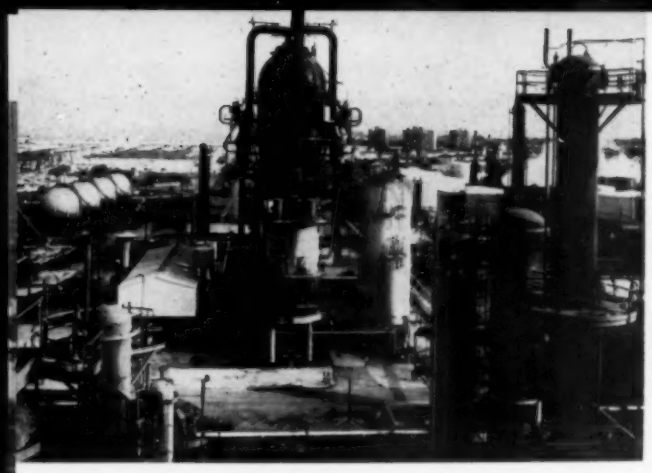
A typical refinery in the Delaware Valley costs about $140,000,000 of which 12 per cent is invested in crude distillation, 18 per cent in lubricating oil recovery, 24 per cent in light end recovery, 4 per cent in blending and packaging, and 42 per cent in utilities and services.

In the majority of plants, the crude oil is first vacuum distilled and then cracked in fluid catalytic type cracking units. In addition, all but one of the plants have thermal cracking, visbreaking, or naphtha reforming units. Sulfuric acid alkylation is used in pref-

*Oil and Gas Journal, March 19, 1956.

An aerial view of Sun Oil Company's Marcus Hook 160,000 bbl per day refinery, with its 360-ft Houdriflow cat cracker unit in central middleground.

One of the largest East Coast refineries is this Gulf Oil Corporation plant.



A partial view of Atlantic Refining Company's Point Breeze refinery, in outskirts of Philadelphia.

The largest capacity cat cracker in the world, 102,000 bbl per day, has gone on stream recently at Tidewater's new "built-from-scratch" refinery near Wilmington, Delaware.

erence to the hydrofluoric process in those plants which are so equipped. Catalytic polymerization is used rather than thermal polymerization. Four refineries in the Philadelphia area have facilities for lubricant recovery, and three refineries produce asphalts. Four of the refineries are listed as petrochemical producers.

The variations in the types of equipment may be due to various things. One of the principal reasons is the policy of the individual company with respect to what types of equipment they think are most desirable to perform particular operations. Also, the product-mix varies with the different companies — one plant emphasizes lubricants while another recovers a large amount of asphalt. Furthermore, the chemical characteristics of crudes from various fields differ and the crudes must be processed differently. Therefore, although all the plants produce a full range of products, they may go about it in different ways to produce particular grades according to their individual specifications.

The growing interest and importance of petrochemicals as a by-product of the refining process is reflected in the Philadelphia area refineries. The number and type of petrochemicals produced at each refinery varies considerably. Even those refineries which are not actually listed as petrochemical producers may act as a source of supply for chemical concerns located in their vicinity. For example, the Freeport Sulphur Company located in Westville, New Jersey, uses refinery gases as a source of sulfur. Petrochemicals that are produced in the area by one or more of the refineries are as follows:

1. Ammonia
2. Cresylic acid
3. Dodecene
4. High aromatic solvents
5. Mixed xylenes
6. Naphthenic acids
7. Nonene
8. Para xylene
9. Petroleum Sulfonates
10. Propylene
11. Sulfur
12. Sulfuric acid
13. Synthetic detergents
14. Toluene

TABLE 1—Details of Philadelphia Area Refinery Capacity.

Company	Crude Capacity	Charge, Barrels per Stream Day: Vacuum dist.	Thermal operations	Cat Cracking Feed	%	Cat reforming	Hydrogenation	Alkylation	Polymerization (Prod.)	Lubes (bbl) Coke (tons)	Asphalt
Atlantic Refining Co..	148,000*	40,000*	—	59,000*[1]	40	12,000*[18] 15,000[14,20]	15,000[13,20]	5,000*[14]	1,900*[13]	5,000*[16]	6,000*[17] 800*[18] 1,500*[19]
Gulf Oil Corp....	183,000*	70,000*	11,200*[2] 22,500[2]	85,000*[1]		16,000*[3] 52,000[3,20]	—	2,800*[14] 3,000[14,20]	3,600*[13]	1,000*[16]	—
Sinclair Refining Co..	102,000	45,000	5,000[1] 27,000[2]	45,000[5]	25	16,000[11]	10,000[13]	—	1,850[13]	—	—
Socony Mobil Oil Co., Inc.....	100,000	43,000	6,000[2]	35,000[6]	25	—	22,000[13,20]	2,300[14]	—	8,000[16]	1,200[18]
Sun Oil Co..	140,000*	—	74,000*[2]	20,000[6] 26,000[7] 28,500[8]		32,000*[12]	—	—	—	11,800*[16]	800*[17]
The Texas Co.....	60,000*	22,000*	9,000*[2] 13,500[2,20]	35,000*[2]		12,000*[3]	6,500[13,20]	1,600*[14]	2,500*[13]	—	—
Tidewater Oil Co....	130,000	—	42,000[4]	102,000[5]		45,000[12]	—	5,000[14]	—	—	—

*Barrels per calendar day

1. Gas oil cracking
2. Visbreaking
3. Naphtha reforming
4. Fluid coking
5. Fluid
6. Thermofor
7. Houdriflow
8. Houdry
9. Platforming
10. Catforming
11. Sinclair-Baker
12. Houdriforming
13. Hydrodesulfurization
14. Sulfuric acid
15. Catalytic
16. Lubes
17. Straight run
18. Unmixed
19. Other

Oil and Gas Journal, March 19, 1956.

Product Distribution and Markets

After refining has been completed, the pattern for the transportation of the products is neither as simple nor as inexpensive as that for crude oil. The products must be kept separate from one another by containers or by the use of dividing agents in products pipe lines. Furthermore, the crude is transported to relatively few destinations while products must be shipped to innumerable markets. The usual methods for shipping products are by tanker, barge, rail, truck, and pipe line.

In the Philadelphia area, an average of 42 per cent of all products are transported by pipe line, 37 per cent by ocean tanker and barge, 16 per cent by truck, and 5 per cent by rail. As is the case with incoming crude, accessibility to the ocean is reflected in the high percentage of products transported by water. These products are shipped to foreign countries and to other Atlantic Coast ports. Barge transportation is used along the Delaware, Schuylkill, and Susquehanna rivers. For short overland haulage tank trucks are used. The tank car is used to only a limited extent in the Philadelphia area for shipment to locations that are not serviced by the product pipe line system. Philadelphia refineries have access to, or partial ownership in, products pipe lines that supply New Jersey, New York, Ohio, and Pennsylvania. (See map.)

TABLE 2—Comparative Transportation Costs for Products Shipments from Philadelphia to Inland Destinations.

Philadelphia to:	Cents per gallon costs in 1949: By rail	By truck	By pipe line
Exton	1.287	0.46	0.12
Mechanicsburg	1.815	1.39	0.19
Kingston	2.376	1.71	0.29
Williamsport	2.739	2.31	0.29
Pittsburgh	3.399	3.94	0.32

Source — McLean, J. G., "The Growth of Integrated Oil Companies," Harvard University, 1954, page 342.

Engineers looking over Sinclair's big refinery at Marcus Hook, Philadelphia's huge industrial suburb.

The trimness of modern refinery units is significant; this 45,000 barrel per day crude unit at Socony-Vacuum's Paultboro, New Jersey, plant is an excellent example.

Ocean shipment is the most economical transportation method. The next cheapest method is the pipe line. Table 2 shows the relative cost of transportation to several inland points by the various methods.

The rail costs are approximately six and one half times as high as pipe line when shipping to Pittsburgh; and, therefore, the pipe line dominates product transportation. The truck is also more important than rail because it is cheaper for all destinations except Pittsburgh.

The development of multiple-products shipment by pipe line has had an important effect, not only on transportation, but also on the number and location of refineries and bulk plants. One company, which had three Pennsylvania refineries in 1930, and approximately 265 bulk plants located in virtually every town of reasonable size within the state, by 1950 had only one Pennsylvania refinery and had reduced its bulk plants to approximately 50. A pipe line, which did not exist in 1930, is now the main artery of transportation. Products are transported by truck from the pipe line terminals to the existing bulk plants. The elimination of refineries, closing of bulk plants, and use of cheaper transportation have made a large reduction in the delivered cost of products.

The Philadelphia area refineries are in the center of the largest petroleum consuming district in the United States. In 1955, District 1 (the East Coast) accounted for 33 per cent of the national consumption of gasoline, 51 per cent of the distillate fuel oil, and 52 per cent of the residual fuel oil. The advantage of the Philadelphia area over other possible locations along the East Coast is apparent when it is realized that 50 per cent of the consumption of gasoline and fuel oils within District 1 is concentrated in the four states immediately surrounding Philadelphia; Pennsylvania, New York, New Jersey, and Delaware. An additional 21 per cent of the District's consumption is found in the states on the perimeter of this core area: Ohio, West Virginia, Maryland, and Virginia. Consequently a refinery in Philadelphia, in addition to the necessary requirement of being accessible to crude carrying tankers, is able to minimize the overland distance required to deliver its products.

Conclusions

The Philadelphia area represents the ideal combination of circumstances for the market-area refinery — a large metropolitan marketing area and access to cheap ocean tanker shipment of low cost crude. Though the capital investment in these refineries is large, it can be justified by the lower fixed cost per barrel of output and the longer period of amortization.

The Philadelphia area refineries produce primarily gasoline and fuel oils. Barges are used for river and intercoastal trade and tankers for ocean shipment. For inland distribution, elaborate systems of products pipe lines are employed primarily.

District 1 is the largest consuming district of the major petroleum products in the United States. Of the possible locations for refineries in this District, Philadelphia is one of the best since it is located in the center of the major consuming states. This has led to the development of the area as one of the major refinery centers in the country. However, the potential of this area has still not been fully exploited and expansion is needed. While consumption of major products in District 1 has increased from 38 per cent to 42 per cent of the national total from 1946 to 1955, refinery production of these same products within the District has declined from 17 per cent to 15 per cent of the United States total. ★ ★ ★

TABLE 3—Imports of Foreign Crude Oil to District 1, July 1956.

States of Imports	Quanity Imported (M of bbl)
Colombia	607
Iran	574
Iraq	1,221
Kuwait	4,238
Mexico	102
Neutral Zone	152
Qatar	626
Saudi Arabia	3,018
Venezuela	14,166
Total—District 1	24,734

Source—U. S. Bureau of Mines.

The Authors

J. J. Schanz, Jr. R. C. Barwick

John J. Schanz, Jr., received a BS degree in mineral economics from the Pennsylvania State University in January, 1948. He was employed as a research chemist with the Beryllium Corporation until August, 1948, when he returned to Penn State as an instructor in mineral economics. He received the MS and PhD degrees in mineral economics in 1950 and 1954. He has been an assistant professor of mineral economics since 1954. His teaching and research has been concerned primarily with fuel economics and the statistics of the mineral industries.

Robert C. Barwick was graduated from the Pennsylvania State University with a BS degree in geology and mineralogy in June, 1952. He served two years as an officer with the Signal Corps following graduation. He returned to Penn State in 1954 and received an MS degree in mineral economics in September, 1955. Since that time he has been Chief of the Minerals Division of the Pennsylvania Department of Forests and Waters. In this capacity he is in charge of all leasing and development of mineral resources on State lands in Pennsylvania.

Planning and Precautions for

Acid Cleaning a Catalytic Reforming Unit

Here's a blow-by-blow account of how a safe and thorough acid cleaning job was done

Donald M. O'Neill
Standard Oil Company of Texas, El Paso, Texas

This paper presented at the Dowell, Inc., Refinery Symposium in Tulsa, Oklahoma, September 18, 1956, describes the acid cleaning of the heaters in the catalytic reformer at the Standard Oil Company of Texas Refinery in El Paso, with particular emphasis on the planning and precautions taken to assure a safe and yet thorough cleaning job.

THE Standard Oil Company of Texas' catalytic reformer is a platinum catalyst unit having a capacity of approximately 5000 bbl per day. No sulfur removal facilities are provided either for the feed to the unit or recycle gas within the unit.

The unit had been operated a total of about 13 months before acid cleaning was attempted. From scale measurements taken at previous shutdowns it was estimated that the feed preheater and intermediate heaters had scale built up to a thickness of about ⅛-in. on the inside of the tubes and that the hottest reaction mix feed heat exchanger had a deposit about 1/16-in. thick on both the inside and outside of the tubes. Based on these scale thicknesses and the various areas involved it was estimated that the system contained approximately 63 cu ft of scale. X-ray diffraction analysis showed that scale samples obtained at a previous shutdown were essentially 100 percent FeS. Calculations showed that in dissolving this volume of scale with HCl approximately 20,000 std cu ft of H_2S would be formed.

The acid cleaning on this unit was entered into with two basic principles in mind. First of all, it was essential that the unit be cleaned safely. Secondly, a complete job from a scale removal standpoint was desired.

Disposal of H_2S: Alternatives

When it was determined that about 80,000 std cu ft of H_2S would be released during the acidizing operation, it was realized that a tremendous hazard would exist if proper facilities were not provided to dispose of the H_2S safely. Several alternative methods of H_2S disposal were considered during the planning stages of the cleaning operation:

1. Release the H_2S formed directly to the atmosphere from a vent line up the depropanizer column at an elevation of approximately 75 ft above plant grade.
2. Flare the H_2S on top of the depropanizer column approximately 75 ft above plant grade.
3. Release the H_2S formed into the refinery low gas system. The low gas system in the El Paso refinery is old and rather complicated since it grew as the refinery grew rather than being designed as a complete system planned for expansion. A small 100,000 cu ft gas holder rides on this low gas system.
4. Caustic scrub the gas formed during the acid cleaning operation.
5. Burn the H_2S in the thermal cracker furnace along with other fuel gas required for the thermal cracker heat load.

In considering the various possible methods of disposal of the H_2S formed, the toxicities of hydrogen sulfide and its combustion product, sulfur dioxide, were given due consideration. The toxicities given in Mark's Handbook for these two gases are:

Toxicity of Gases
(All figures ppm)

	Rapidly Fatal	Max. Conc. ½-1 hr.	Max. Conc. 1 hr.	Max. Conc. for Prolonged Exposure
H_2S	1000-3000	500-700	200-300	20
SO_2	400-500	50-100	—	10

In considering the alternative H_2S disposal methods it was assumed that it would be possible by controlling the quantity and strength of acid in the system at any one time during the cleaning operation, to control the evolution of hydrogen sulfide gas to a maximum rate of 20,000 std cu ft per hr. All design calculations for the disposal system were based on this maximum rate.

Because of the high toxicity of H_2S and SO_2 it was felt that neither of the first two methods of disposal of H_2S were acceptable. Therefore, serious consideration was given only to the latter three methods listed. Because of the complexity of our refinery low gas system and because of the possibility of small leaks occurring any place in this system, it was felt that a dangerous local H_2S concentration from a small leak could occur almost any place within the refinery if the gas from the clean-

ing operation were put into the low gas system. For that reason this method of disposal was rejected. In our particular situation caustic scrubbing of the gas from the acidizing operation had two serious disadvantages. First of all it was felt that scrubbing with caustic did not permanently assure us of having eliminated the hazard. With our waste disposal ponds, there was always the possibility, though remote, that the relatively large quantity of sodium sulfide formed by caustic scrubbing the H_2S might be contacted at a later date with acid with the release of hydrogen sulfide. The second disadvantage in our particular case was that we did not have an adequate caustic scrubbing system readily available to handle the H_2S at the expected evolution rates.

Burning H_2S in Furnace Best Disposal Method

From the above considerations it appeared that each of the other alternatives had serious disadvantages. The alternate of burning the hydrogen sulfide in the thermal cracker furnace along with the incremental normal fuel gas requirements, on the other hand, appeared to have important advantages. The SO_2 formed from the combustion of the hydrogen sulfide would be considerably diluted with other flue gases from the furnace, it would be released at a relatively high elevation above the plant as compared to some of the other alternates, and, in addition, it would be released at a considerably higher temperature so that the gas would tend to rise and be dispersed in and diluted by the atmosphere.

However, calculations showed that the flue gas leaving the thermal cracker furnace during the acidizing operation would contain approximately 2 percent by volume of SO_2 when the H_2S was being burned at the maximum design rate of 20,000 std cu ft an hr. Since this concentration is an extremely dangerous one, judging from the data from Mark's Handbook, we wished to assure ourselves by whatever calculation methods were available that dangerous concentrations of SO_2 would not exist anywhere at ground level. Calculation methods from two separate articles were used to independently check the concentration of SO_2 that might exist at ground level during maximum evolution of H_2S. The first of these articles was entitled "Stacks for Pollution Control" in *Chemical Engineering*, February 1952. The other article used was titled "Dispersion of Gases From Tall Stacks" by Thomas, Hill and Abersold from *Industrial & Engineering Chemistry*, November 1949. Both of these references used equations originally developed by Bosanquet and Pearson. Calculations using these two sources showed that the concentration of SO_2 at ground level would be well within safe limits.

We were still concerned with possible hazard to personnel on elevated structures around the refinery particularly on the Houdry catalytic cracker structure which was within 500 ft directly west of and taller than the thermal cracker stack. In order to minimize any possible hazard to personnel on the catalytic cracker structure, orders were issued making it mandatory during the day of the test for any operator who had to go up on the structure to have a canister type gas mask with him at all times. Furthermore, if the wind was in such a direction or uncertain in direction or strength so that a definite hazard was considered to exist on the structure, it was mandatory that any man going up on the structure wear a self-contained emergency air supply, with air mask available for instant use should he encounter any concentration of SO_2 gas.

The Author

Author Donald M. O'Neill became the lead engineer at Standard Oil Company of Texas' El Paso refinery in 1953. He handles engineering for a variety of plant additions, alterations and maintenance jobs in addition to supervision of technical aspects of other engineers' work. Attending Washington University of St. Louis and University of Michigan, O'Neill received his BS in chemical engineering from the latter in 1943. Except for two years' World War II service as a naval officer in the Pacific Theater, he was with Standard Oil Company of California in the General Engineering Department until 1953, when he shifted to Standard of Texas. Mr. O'Neill is a registered professional engineer in the State of California, belongs to the AIChE, and is a member of the Tau Beta Pi and Phi Lambda Upsilon honorary fraternities.

Safety Precautions and Control Measures

It was considered that having the personnel, both in the area and in the surrounding plants, informed of what was going on was essential to a safe job, should any large leak occur. For this reason a memorandum was issued over the refinery manager's signature describing the operation that would be conducted as well as the safety equipment that was provided in the area and other pertinent information. Temporary flow meters were provided to meter the flow of hydrogen sulfide gas going to the thermal cracker furnace to facilitate controlling the release rate to within the desired maximum 20,000 std cu ft an hr. The depropanizer column within the catalytic reformer unit was used as a surge vessel during the acidizing operation. It was selected because it had sufficient volume to contain the entire volume of the system being acidized. Therefore, should the reaction get out of hand at any time so that gas was being formed faster than it could be released, the depropanizer column formed a reservoir sufficiently large to handle all the liquid in the system. The gage glasses on the bottom section of the column were replaced with tubular gage glasses without check valves. This was done in order to minimize the possibility of reading a false level because of plugged leads or valves.

A public address system was installed in the area for the shutdown so that it would be possible to give immediate instructions to all personnel working in the area in case of a serious leak or other emergency conditions. The complete acid cleaning system including all temporary lines and equipment were hydrostatic tested prior to the acid cleaning operation, blown out with air, and displaced with nitrogen to eliminate the possibility of an explosive mixture occurring during the inital gas evolution period.

Description of Cleaning Operation

As the result of laboratory tests run at 100 F with HCl concentrations from 5 to 25 percent on scale samples removed during a previous shutdown, it was decided that initial contacting should be done with acid at no higher than 10 percent concentration. Depending on gas evolution rates, acid strength would be increased and the acid heated to a maximum of 160 F. In order to assure a complete job, the final circulation was to consist of about an hours circulation of 20 percent acid at 160 F.

The actual acidizing was started at about 10.30 a.m. by slowly charging 10 percent acid into the system, circulating and then dropping spent acid at a concentration of about 2½ to 4 percent. This process was followed for approximately 2 hr. During this time the H_2S was being produced in surges ranging up to a maximum rate of about 12,000 std cu ft an hr which was well within the desired maximum of 20,000 std cu ft an hr rate. No heat was added during this initial period of cleaning. Solution temperatures were in the neighborhood of 85 to 90 F.

Shortly after noon after 2 hr of acidizing, the acid strength was increased to 13 percent with acid being continually pumped into the system with spent acid at about 3 percent concentration being dropped continuously to disposal. Control over this operation was being

maintained by watching the gage glass on the depropanizer. Within a few minutes it was noted that the depropanizer bottom pressure had rise to about 15 lb which indicated either that the level had risen in the depropanizer column or that the pressure drop in the gas disposal line to the thermal cracker furnace had gone up due to increased gas production.

However, at this time the level was still visible on the gage glass and a check of the gas flow showed that the H_2S production had not increased significantly. Within a minute or two large clouds of yellowish-white smoke were observed being emitted from the thermal cracker stack. Acid was reported heading over through the gas line into the furnace. Pumping was stopped immediately and spent acid drained from the system as rapidly as possible. The pressure at the bottom of the depropanizer column reached the maximum of about 35 psig. Of course, the gas quantities indicated by the meter during this period were not correct because of the acid carryover. At this time the level was still visible on the gage glass. In spite of the fact that a tubular type gage glass had been installed and that the ball checks had been removed, the gage glass had become plugged and was not reading a true level.

As near as could be determined afterwards, the quantity of acid in the system at the time when acid started to carryover into the furnace was less than the volume of the depropanizer column. Apparently a high level had built up in the depropanizer column and a rapid release of gas below the surface of this acid had caused the column to flood, heading acid over into the system going to the furnace. From this time on the gage glass was not used to control the addition and dropping of acid. Instead two pressure gages were used, one on the bottom of the depropanizer column and one on the gas knockout drum in the line to the thermal cracker furnace. The difference between these two pressure gage readings was used to indicate approximately the level of liquid in the depropanizer column. Although the gage glass was unplugged and placed back in operation, it again became plugged showing that the use of the pressure gages was more reliable for level indication.

Circulation of the system was started again about 3:30 that afternoon. Ten to 12 percent acid was charged and circulated and dropped when spent to about 2 to 4 percent. During this period small surges of H_2S up to a maximum of 3000 to 4000 std cu ft were given off, indicating a greatly reduced activity. At about 5:00 p.m. that day 10 percent acid was used and was heated with open steam up to 160 F and circulated.

There was very little activity during this period until 7:00 p.m. At this time it was decided that the cleaning operation was essentially complete. To make absolutely certain, approximately 2000 gal of 20 percent acid were charged into the system, dropping out enough 10 percent acid to make room for this addition. The system was then circulated and heated to 160 F. There was no evidence of gas release shown on the meters. When the system had become thoroughly mixed, the acid concentration leveled off at about 18.5 percent. At this time, it was considered certain that the acidizing operation had been completed satisfactorily. However, the circulation was reversed and another sample taken for titration after about 30 min. This sample showed a concentration of 13.5 percent. The system was circulated with additional samples taken at about 15 min intervals.

The samples all showed the concentration to be approximately 13.5 percent. Apparently when the circulation was reversed the last time, a pocket of unreacted material had become exposed to the acid causing the drop in the strength of the acid in the system. Because the meters were sized for relatively high flow rate and were square root reading meters, there was no indication of gas production during this period. At 10:00 p.m. additional strong acid was added as the system was circulated to bring the strength of the system back up to about 16½ percent. This was circulated forward and backward through the system for about an hour and a half at a temperature of 160 F with no drop off in concentration. At 11:30 p.m. it was decided that the reaction was complete, and the acidizing operation was terminated.

The acidizing operation was followed by the usual washing, neutralizing, and passivating operations. During the washing operation considerable fine carbon-like material was washed out.

Results

Since all of the furnace coils in the heaters are made up with welded return bends at both ends of the tubes, there was no positive way of assuring ourselves that the job was 100 percent effective. However, several temporary connections had been tied into the permanent piping to complete the acid circulating circuit. Wherever these connections were removed, the inside of the lines were found to be completely free from scale. The only residue found any place in the system was a very small amount of fine carbon-like material in the dead spot in the channel of the reaction mix-feed heat exchanger which was cleaned as a part of this system.

Audigage checks by our inspection section of a number of the furnace tubes showed no evidence of internal scale. Furthermore when the unit was placed back in operation the skin point temperatures of the tubes were comparable with skin temperatures when the furnaces were first put in service.

Our inspection section reported the following metal losses occurring on the various materials in the system during the acidizing operation. It should be pointed out, however, that corrosion data taken at previous shutdowns were used to divide total metal loss found between that from corrosion during operation and that from the acidizing operation.

Carbon Steel	.002" to .003"
1¼% Chrome Moly	.002" to .003"
5% Chrome ½@ Moly	.003"
11 to 13% Chrome	as high as 0.150"

Recommendations and Conclusions

In summarizing the experience obtained during this cleaning operation we feel that, although hazards do exist chiefly because of the hydrogen sulfide released during the acidizing operation, that with proper preparations and precautions the job can be done safely and without undue hazard to personnel. We do recommend the following in preparing for any similar acid cleaning operation:

1. That extreme care be taken in assuring that a safe method of disposing of the H_2S is provided.
2. That a surge volume be provided in the system at least equal to the volume of the system to be circulated.
3. That the system be set up so that gage glasses do not have to be depended upon for control of the acidizing operation.
4. That careful control over the strength of the acid being pumped into the system be maintained at all times. The initial acid concentration in excess of 10 percent should not be used.
5. That all possible 12 percent chrome trimmed valves and equipment be removed from the circulating system because of the ineffectiveness of present inhibitors in protecting this material.
6. That all personnel working in the cleaning area and in the surrounding units be advised of the operation that is taking place, of the potential hazards involved, and the safety measures and equipment provided. ★ ★ ★

Modern asphalt stripping still unit (below), at Empire State Oil Company plant, Thermopolis, Wyoming, almost the entire production of which is asphalt and road oils from Mountain "Black Crudes." **Vacuum distillation unit** (right) at British Petroleum Company's South Wales refinery; overhead from this unit is lubricating distillate; bottoms may be reduced to asphalt or road oils.

P 756.

ASPHALT

PRIME BUILDING MATERIAL FOR NEW NATIONAL HIGHWAY SYSTEM

Edwin J. Barth
Asphalt Consultant
New York, New York

ASPHALT is one of man's oldest engineering materials. Studies of asphalt paving structures bring out the need for a greater knowledge of the bituminous binder itself as well as bituminous roofing materials and various physical properties.

Answers to such questions as, what makes some asphalts "tick," why do others show poor roof-durability, and and is pavement disintegration mainly a physical proposition? are awaiting a concise lucid answer.

An approach is presented here to a better understanding of what asphalt (bitumen) is supposed to do; we also wish to know more about its physical properties, and to describe these accurately. The present approach will concern itself with various physical aspects of asphalts. Certain changes in our thinking will be in the making. What these changes are will be of tremendous importance to both the producer and user of asphalt.

This article deals with new suggested studies on asphalts and their use as particularly related to asphalt pavements.

Pavement Failure

The immediate cause of pavement disintegration appears to be physical in nature. We have physical forces tending to cause physical disruption in a structure designed according to certain principles.

We assume the aggregate is inorganic; that it is well-graded, inert, and of proper strength, etc. However, the organic portion of the pavement, or asphalt binder, needs considerable study and investigation. Such studies logically lead to explanation of failures in paving structures as well as in roofing materials, coatings, membranes, canal lining, etc. What the binder is failing to do, or what it lacks for proper performance needs clarification. Pavement break-up has concerned paving and research engineers for many years.

Reiner[1] for instance in pavement studies states that:

"Asphalt Road surfacings fail through either:

1. Excessive deformation, or
2. Disintegration which ultimately is due to either:
   - A. Rupture through the asphalt —mortar, or through the films of bitumen coating the aggregate, or
   - B. Rupture of the adhesive bond between the asphalt mortar, and the surface of the aggregate.

   Type (B) usually arises from the action of water in breaking down the adhesion."

The bitumen must deform sufficiently in order to carry through or transmit traffic loads along with the solid aggregate to the foundation below; that is one citerion.

Deformability at low temperatures was studied as a distinct or characteristic property of asphalts by Hughes & Faris, Jr.[2] Deformability appears to be

somewhat related to susceptibility to temperature changes of a bitumen as one of the facts discovered. Deformability will be more fully discussed below.

What Is Rheology?

Centuries ago, a learned observer of Ephesus stated that "Everything Flows." Asphalts, tars, pitches, and even granite rocks are included.

Flow of materials and its studies is termed Rheology, and as a science its content is quantitative. It describes in absolute or rheological units properties of materials which are usually at normal temperatures not strictly solids nor thin liquids, but which are in an intermediate, soft or plastic state.

Asphalts are required to perform in a "service range" just about in this intermediate semi-solid range, over a fairly wide span of temperature; above the upper limits of service temperature we require good fluidity at elevated or proper mixing temperatures for hot mixes; at the low extreme of useful service ranges of temperature the binder is not supposed to become hard, brittle, friable, flaky and not crack. It is a large order, indeed.

In this wide service range bituminous binders show various degrees of solidity, flow, elasticity, temporary hardening, thixotropy, age-hardening, brittleness, etc. How are these isolated descriptive properties related?

Research work by several investigators is in progress unifying some of these isolated descriptive terms and test methods into a system of comprehensive asphalt rheology, wherein such properties receive mathematical treatment, and are described in scientific units. Moreover, the properties separately considered may well be a condition much dependent on viscosity for instance, and could be described in units related to viscosity units.

Empirical Specifications

Present day bituminous specifications consist of empirical test procedures and requirements built up over the years by rule-of-thumb thinking.

True, there have been some refinements in asphalt test methods from the primitive "chewing test" which required no apparatus at all but a strong set of teeth, and anybody's mouth was always at a constant temperature.

Finally those materials which seemed to show a good long service or road record were looked upon as "Standard" to be copied. Their tests were taken as worthy to have in any good specification for paving asphalts; in this way good service performance was assured to some degree.

We are in a rapidly-developing transitional stage moving up fast from primitive beginnings; this is due to new conceptions concerning asphalts—what they are and how they function. We are beginning to define their properties in precise scientific (engineering) terms.

With new "measuring sticks" we should be in good position to diagnose pavement troubles, asphalt disintegration, more efficiently describe what a satisfactory binder is and to obtain an insight on how to enhance "Inferior" asphalts.

Big Job For Thin Films

Assuming a properly designed asphalt — sand mix with correct bitumen contents, void contents, etc., the average thickness of an asphalt film on a sand grain or small stone is about 0.0005 to 0.001 in.

At this small unit of film thickness the asphalt must perform satisfactorily under a variety of climatic and mechanical conditions. Asphalts like many other organic materials behave quite diffierently in the thin film condition than in bulk; in thin films we have rapid absorption of gases; water permeability and gaseous diffusion become evident; surface energy effects, capillarity, and the presence of van der Waal's forces play a vital part in cohesion phenomena , not to mention chemi-sorption.

This is the clue, as it were, to test asphalts for as many properties as possible, if not all, in very thin films or in sand mix rather than in bulk; in order to divorce the effect of sand structure in test work, one can carry out tests of asphalt films on plates or slides of inorganic materials of definite composition — such as plates of silica, polished granite, mercury or even water.

Working in this way, C. Mack[2] describes advanced research work in determining maximum cohesion force as a function of the amount of asphalt, in thin films on silica and limestone surfaces. This investigator found a 60 penetration asphalt behaving as a solid in experiments separating granite plates coated with thin films of various thickness.

Definition of Asphalt Function

We define what asphalts must do to perform or function properly by saying that the film must:

1. Readily deform without rupture in order to resist thermal stress due to volume changes, and it
2. Must recover elastically from these small deformations to absorb shock loads, and not by plastic flow.[3, 4]

For visco-elastic materials, such as most asphalts are, the recovery takes place over a considerable span of time and is most often partial.

In the functional requirements thus stated, these thin films also act as an expansion joint on each stone or sand particle for the entire pavement — with millions of surface joints per square inch of mix. The above is our fundamental rheological (physical) requirement definition for asphalts. Translating these requirements into a proper scientifically-sound test procedure, and expressing the asphalt property so measured in basic rheological units, is the work of the rheologist. The need for a unified rheological system for asphalts employing concise absolute units of measurement was first pointed out in 1935 by Czagoly, Ubbelohde, Ulrich, Walther, Zichner & Hoepler.[17]

What Rheological Properties Should Be Determined

Functioning as they do, or are supposed to do, over a wide "service range," asphalts exhibit various physical states and properties which are viewed as derived from the concept of viscosity — our fundamental expression of fluid flow.

Viscosity. Determining the viscosity of asphalts requires special handling. It must be determined under suitable conditions at different temperatures, etc.

Most asphalts exhibit a truly fluid state only at higher temperatures or under stirring conditions called rates of shear, definite types of stress the material is put under until equilibrium or viscosity is constant. This is especially true where the viscosities run into many millions of units, called centipoises (cp). The rates of stress and shear action, in time, etc., are given for such measurements describing an asphalt viscosity range. Table 1 indicates the size of these viscosity units at various temperatures for a 100-105 F MP asphalt.

TABLE 1—Viscosity Vessels Temperature Using Stormer Viscosimeter.

At F	Viscosity (Cp)
257	1,021
210	21,000
167	64,000
122	600,000
83	4,750,000

For very soft asphalts with viscosities below 10,000 poises, the test can be made using the Falling Ball or Hoeppler type of viscosimeter[5] for low ranges.

For use with hard solid asphalts, or those that are gels in a melted condition, a rotary type of viscosimeter among which is the Stormer or more recently, the much discussed "modified Stormer" viscosimeter, is most suitable. The asphalt sample to be tested

is under a constant rate of shear or constant shearing stress until equilibrium is reached; the mean shearing stress should be constant for a given load.

Space does not permit a description of various suitable instruments now being employed for the more viscous and gel types of asphalts.

Considerable literature exists concerning these types of apparatus, to which the reader is referred.[6]

A very useful viscosimeter recently developed by Shell Oil Company,[16] of a micro-type is well adapted for rheological study of asphalt; it has the surprising working range of 10 poises to 10^{11} poises, and these viscosities can be determined from 32 to 140F; in addition only 10 milligrams of sample are required for test.

In the ranges of 250 and upward, most asphalts are thin Newtonian liquids, and in this range the Saybolt Furol viscosimeter can be used for asphalt manufacturing and paving plant uses. For accurate work a Fenske type Ostwald bulb viscosimeter is satisfactory.

Absolute viscosities in poises for several 65 penetration asphalts from various sources are shown in Table 2.

TABLE 2—Absolute Viscosities at 77F, of 65 Penetration Asphalts. (Stormer apparatus used; stress of 200 dynes per cm^2.)

Asphalt	Viscosity (N) (Poises x 10^6)
California	2.1
Lobitos	2.7
Venezuelan	2.6
Mexican	4.3
Blown Mexican, fluxed	13.9
Egyptian	3.7
Egyptian heavily cracked	1.6
Trinidad fluxed	3.6
Cuban fluxed	84.1
Coal-tar Pitch	2.7

Rheological Diagrams

We employ a series of absolute viscosities (or sometimes without determining viscosity) to plot graphically shearing-stress at various shearing rates.

Plotted arithmetically, shearing stress in dynes cm^{-2} as abscissa against shear rate in reciprocal seconds as ordinate will result in:

1. Straight lines for the viscous Newtonian types (see Table 3 asphalt A), and
2. Curved lines for the Visco-elastic and gel type asphalts (Table 3, B and C)

When these values are plotted on log-log paper, both types of asphalts show as straight lines.

Diagrams for Complex Flow

These curves are valuable in describing a property of asphalts not commonly referred to — namely, complex flow. The slope of the line for Newtonian flow (slope with respect to rate of shear axis) is always 1.0, and designated complex flow c, being 1[4]; for asphalts such as the gel or visco-elastic types, which deviate from the purely viscous flow behavior to various degrees, complex flow c is less than 1.0. There we have numbers to describe a change in flow state.

Fig. 1 shows curves by R. N. Traxler on log-log graph for asphalts of various complex flow c; the data can be determined at 77F, or at 100F or 122F temperature. As the gel or rubbery structure of an asphalt, such as a blown material increases (complex flow increases) the value of c decreases.[3]

The terms Newtonian, elastic, sol, gel, etc., have been applied to various asphalts in our discussion so far; it is in order before proceeding therefore to describe in some way what sort of asphalts these are. Table 3 shows three typically different rheological types, with their constants, and with the additional empirical test values for penetration, melting-point, and penetration-index (Shell).

TABLE 3—Properties of Three Rheological Types of Asphalts[4]

Asphalt	A	B	C
Colloidal type	Sol	Sol-gel	Gel
Rheological type	Newtonian	Visco-elastic	Elastic
Melting-point (R&B)	122F	131F	150F
Penetration-index (Shell)	-1.2	0.2	2.3
Penetration, 77F	50	55	53
Viscosity, 77F megapoises,* at power input of 1000ergs sec^{-1} cm^{-3}	3.2	4.4	23.0
Degree of complex flow c	1.0	0.8	0.5
Asphalt aging index (a)	0.02	0.08	0.21
Elasticity, (Relaxation) one-half time, sec	1.0	4.0	13.0

*1 Megapoise = 1 million poises.

(a) Asphalt Aging Index is the slope at 100 hours of a log-log plot of viscosity vs time in hours.[4]

The value of rheological diagrams are important in obtaining a physical picture of the "inherent mechanism" of an asphalt, under stresses and shear in thin films.

Asphalts In the Cold

As asphalts cool from the thoroughly fluid state, at 200 to 350F, to the melting-point, and then from there to room temperature, structural changes take place — in some asphalts rapidly and in others very slowly; discounting the effect of age-hardening which complicates the picture, some asphalts eventually at low temperatures attain a glassy brittle state, the Newtonian flow types, while the gel types, with complex flow c values of about 0.7 or less cool to rubbery spongy materials with much lower brittle points. Most paving asphalts are "intermediate" in type or visco-elastic, but many at low temperatures nevertheless are exceedingly hard and brittle already in bulk form not to mention that they may well be splintery or friable in the form of thin films.

Complex flow c determinations can be made without determining the viscosity; load in grams (proportional to shearing stress for any certain instrument) is plotted against the angular velocity on log-log paper to obtain complex flow constant c.

Constants giving valuable information as to complex flow and perhaps somewhat related are other numerical values of a different magnitude such as those developed by Mack,[7] and designated as constant "n." Hughes & Hardman[8] state this constant is the reciprocal of constant c, discussed above.

Still other entirely different systems of rheological pictures of an asphalt are those employing a "stiffness modulus" as proposed by van der Poel,[9] based on the penetration-index factor of Pfeiffer & van Doormal.[10] "Stiffness Factor" itself relates melting point and the penetration-index, and appears to be of good engineering value in designing paving, mastic and blown asphalt roofing mixes.

Age-Hardening

This is a term derived from rheological diagrams similar to those for complex flow c; it is the slope of a log-log plot of viscosity vs time at 100 hours. (See Table 3.)

Asphalts harden with time even without losing a trace of their oily constituents; this hardening can be in most cases almost completely destroyed by heating and by mechanical action. These forces break up the "structure" of the components in an asphalt, which has developed on standing. Again this build-up of so-called structure is greatest with the gel type of thoroughly blown asphalts; paving asphalts, however, also depending on origin (asphalt B, Table 3) show age-hardening over a period of time. It has a very important bearing on service-life of pavements.

The asphalt Aging Index is a valuable constant to determine on samples of extracted bitumen, and on new or unknown asphalts for predicting hardening and service-life.

The magnitude of the values are shown in Table 4, in relation to complex flow c.[4B]

TABLE 4—Asphalt Aging Index vs Complex Flow C of Newtonian Visco-Elastic and Gel Type Asphalts.

Asphalt	C	P	Q	I
Aging index	0.017	0.023	0.073	0.183
Complex flow c	1.0	0.95	0.85	0.50

Age hardening, due as it is to an internal "structure" developed on standing, is very much dependent on the source of the asphalt (crude ori-

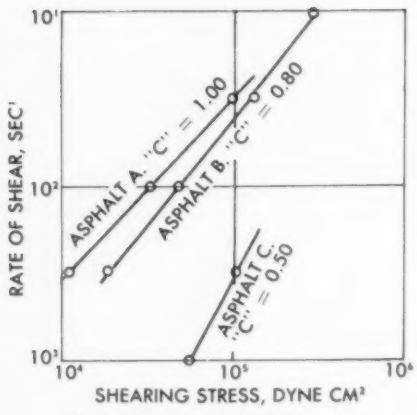


FIG. 1. **Rheological diagram** on log-log coordinates.[3]

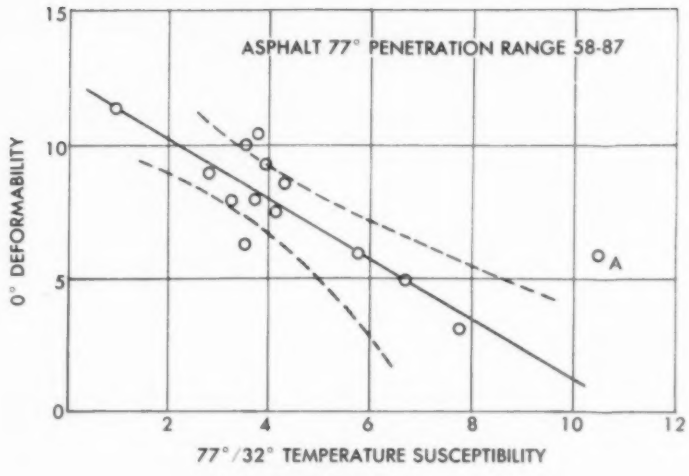


FIG. 2. **O° deformability** vs susceptibility.[2]

gin); next in importance is whether our asphalt is carefully vacuum-distilled or "air-blown," or if it is a reduced cracking-coil tar.

Elasticity

Elasticity in asphalts has been a subject of research as early as 1914.[12] This is a complicated rheological property related to elastic recovery. Unvulcanized rubber, for instance, shows almost complete and very rapid elastic recovery; with most asphalts total recovery is not complete, and takes appreciable time.

This property is pronounced in certain highly oxidized asphalts; at one time "rubber substitutes" consisted wholly of oxidized asphalts.

Relaxation of the stress after an asphalt has been deformed was investigated by Romberg and Traxler[13] using a rotary viscometer.[14]

High elasticity is shown by high values of relaxation times; the latter appear to be related to a high degree of complex flow c (low value for c).

The property of elasticity almost absent in Newtonian asphalts and present to some extent in paving asphalts will need correlation in paving and road service; it is possibly one more phase of "structure" in an asphalt, already described in the form of complex flow c.

A useful rotating cylinder viscometer is that of Lee and Warren[6c] Viscosities from 10^3 to 10^8 and elastic recovery of two types can be measured at various rates of shear and stress with this instrument.

The rotary viscometer is also well adapted for this evaluation. Rather than measure elasticity, or the relaxation time, as such, theoretical reasons suggest determining instead the value which is the time required for the shearing stress to decrease to one-half of its orginal value. This is called the "relaxation one-half time."

Table 5 shows interesting rheological tests relating the properties discussed so far.

TABLE 5—Rheological Constants of Three Types of Asphalts.[13]

Asphalt	Steam refined	Air-blown	
Melting-point (R&B)	122	150	179
Penetration, 77F	53	53	48
Ductility, 77F	200+	8	0.2
Viscosity, 77F, megapoises			
S=0.1	3.0	5.7	7.4
FS=1000 ergs	3.1	22.0	94.0
Complex flow, c	1.0	—0.50	0.35
Relaxation one-half time, sec.	1.	20	66.

Temperature — Susceptibility

It has already been suggested to employ a series of curves graphing temperatures at which a series of absolute viscosities are obtained.

Of the empirical procedures the method of Nevitt and Krchma[15] is also a most useful method using the engineering Kinematic viscosity units and absolute temperatures; an index of susceptibility or viscosity—temperature susceptibility coefficient is obtained.

Deformability

The reader will recall the fundamental definition of properties desirable in asphalts—that of deformation without rupture.

This recalls to mind various empirical beam or bending tests made on materials such as steel, plastics, cement, etc.

A large series of asphalts of various origins were studied exhaustively by Hughes & Faris, Jr., in a series of deformation tests.[2] Deformability values were obtained at various rates of deformation of narrow specimens of asphalt-sand mixes at low temperatures such as 0 F. Of greater value were the results obtained at the low-applied-rates of deformation, rather than the hammer effects of empirical impact tests made in the past by other investigators.

These investigators[2] have shown that: (To quote verbatim): "... Low deformation rate thermal expansion type of deformation is much more critical for asphalts because:

1. Failures occur at lower magnitudes of deformation.
2. It varies in a logical manner with penetration. (A 20 penetration asphalt showed up to be very inferior.)
3. It distinguishes between asphalts from different crude sources in a manner consistent with service experience.
4. It exhibits a reasonable temperature effect, and shows a general relationship to the temperature susceptibility of the asphalts."

Temperature-susceptibility in relation to deformability, taken from Hughes and Faris, Jr., data is shown in Fig. 2.[2] It appears to indicate that asphalts desirable as to deformation within reasonable limits lie in the low penetration — ratio area. Further research work is needed along these lines for the correlation with asphalts of long service record.

Research work is needed to establish the relationship of deformability with the previously discussed rheological constants. It may be that this isolated term or the separate property called "deformability" is probably dependent on viscosity and complex flow relationships. Deformability concept itself should be translated over in rheological units, if possible.

Other rheological properties of asphalts are:

Work-Hardening
Thixotropy
Syneresis, etc.

Work-hardening and thixotropy are probably related physically. The term thixotropy describes a condition shown not only by asphalts, but also by many other industrial products. When bitumen is stored for a length of time, undisturbed, it will "harden" with age. If the sample is now heated, stirred (molten), worked mechanically (shock, vibrational forces, etc.) it will revert to its original state before aging; it may or not always revert 100 per cent to its original state. In doing this the material is said to be Thixotropic. Plotting rheological diagrams from viscosity data will reveal thixotropy.

Both properties are related in some way to viscosity, complex flow c, etc. The relationships need to be correlated.

Syneresis, which is a bleeding of the oil portion of the bitumen of which it is a constituent is a term more commonly used in the roofing than in the paving industry. Bleeding is often manifest with newly blown or with weathered roofing bitumens.

In paving-asphalts, however, that have "aged" (disintegrated pavements), oil exudation is often present. We should consider a factor here usually not thought of in connection with paving, and which may initiate aging effects: — Namely, whether certain fillers or fine aggregate may not act as a filter in absorbing the heavier portions of bitumen, thus freeing the oily constituents. The latter in this "free condition" then evaporate or oxidize on their own. We know many finely-powdered or even coarse solids absorb constituents out of petroleum oils (oil clay-bleaching, chromatography, etc.). In addition there is the conception, and it is not new, that clays, earths, dusts, some sands, the oxides of iron, vanadium, nickel, etc., are catalysts that cause polymerization, thickening or hardening, etc. This phenomena is unrelated to absorption.

Mention of this is made here in connection with syneresis, Oliensis spot test, etc.

New Specifications for Paving Asphalts

On a mere rheological basis of evaluation a satisfactory, highly desirable bituminous binder, for top performance, is one showing:

1. A low complex flow (high value of c) in the upper ranges of temperature; say from approximately 160 F onward to its point of high-fluidity (low viscosity)—Newtonian type.
2. The same material will show a fairly high complex flow c (low value of c)—elastic type—in the service ranges of 150 to 0 F, and in addition, in the very low ranges down to –30 F.

Proper viscosity limits should be set also for these very low ranges of temperature.

Bitumens fulfilling approximately such requirements are available; research work on such materials is under way.

The remaining items in the specification for such a material, that is, the rheological constants also to be included are relaxation—half-time, work-hardening, as well as the viscosity—ranges, etc. They will be determined by relations based on the prime test or most important service characteristic of the asphalt desired. Stress-strain graphical analysis will be most helpful.

The user and manufacturer of asphalts alike will probably continue using the penetration test in this transitional period. However, most technologists are already more conversant with absolute viscosity units than with the penetration test. A most progressive advance is the use of the rotational and similar type viscosimeters built into pipe lines, tanks or vats to give instantaneous readings or long distance automatic recordings of the viscosity of the asphalt from a still, blending or storage tank.

Basic Requirements for Asphalts

We have discussed so far the rheological or physically-based flow considerations of an asphalt. For the paving engineer and roofer these items are the "inherent" properties that must be adequately described for the specific uses of the asphalt under consideration.

In addition to the above rheology we have three other requirements, perhaps to our readers, quite self-evident. These are listed below. Tney are mentioned from the engineer's point of view, and apply to any asphalt and to any product of other name, make-up, composition, or origin for use in paving work.

The three basic definite requirements needed for any asphalt are:

1. Satisfactory "flow properties" in the temperature ranges required (rheology).
2. Maximum adhesion to dry and wet aggregate, rods, fibers, felts, glass-wool, etc. (Physics of surface phenomena.)
3. Maximum durability (high resistance to oxidation; chemical).

Once each of these three specific qualities of an asphalt are expressed numerically in scientific units, and the proper limits set for each, we shall have obtained a coherent definite picture of what that particular asphalt will do in that particular application.

Research Urgently Needed

There is an urgent need for a considerably greater output in research work on the asphalt-sand mix itself — in problems not yet answered on the engineering aspects of road surfaces. Properties measured there show reflections of certain, or again as yet ill-defined properties of the binder. We like to think of this engineering aspect as work to be done with the bitumen itself in the form of thin films, mentioned in the first portions of this discussion.

Solutions of these problems will be greatly aided by several new techniques recently developed. One of these is the determination of the viscosity of the bitumen as it is deposited on glass slides after evaporation of the solvent used in extracting it (the bitumen) from a pavement; distillation of the solvent, usually in large quantities is entirely avoided.[16]

Another new technique uses rapid charges of high-frequency ultra sound passed through the binder; energy absorptions are measured which have been related to various physical states, such as viscosity, elasticity, etc.[18]

Unified Rheological System Necessary

Additional tests such as low-temperature deformability, film cohesion, etc., which also appear important should be resolved into expressions or relationships based on viscosity, complex flow, and elasticity expressed in rheological units.

Future research by highway departments and asphalt refinery technologists should concern itself to reduce the number of unnecessary tests; and to draw up specifications for specific uses of asphalts of all types, expressed in two or three basic or prime tests, in absolute units.

This type of research work should also in the meantime develop a concise asphalt rheology, consisting of rheological conceptions mathematically described in proper rheological or absolute units. Tests such as have been discussed need to be unified, using as basis for relationships the viscosity and complex flow property as a start in this approach. Two or three such "constants" may well express all the necessary rheological properties called for in high grade products.

Empirical tests, rule-of-thumb thinking and primitive procedures existing as they do in present-day specifications,

should be supplanted as rapidly as possible by using concise engineering or rheological units.

The mechanical or engineering research data obtained or already known for the asphalt-sandmixes, will be further "processed" by the asphalt refinery rheologist into limits set for the rheological properties of the binder; and these incorporated in modern scientific specifications for engineering design.

The manufacturer of asphalt also will be much concerned with basic research seeking also the answers to above items (2) and (3) as well.

Given a durable asphalt properly manufactured for:

(1) Controlled composition, (2) High oxidation resistance, and (3) Highest possible adhesion, we shall look to the asphalt rheologist to spell out the ideal asphalt for engineering applications and roads of the future.

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Automation Speeds High Temperature Piping Design

James A. LeVelle, *Engineering Editor*

HIGH temperature process piping systems and power plant piping systems used by the petroleum refining industry, petro-chemical, and other industries, are posing some of the most complex problems that mechanical engineers are called upon to solve. The sole reason for this complexity is the expansion of metals with rising temperatures under increasingly high temperature and pressure conditions of use.

Proper provisions for safe distribution of thermal stresses in piping have taken skilled stress analysts as long as a month or more to complete complex design computations in order to satisfy all code requirements. These computations are almost completely independent of heat expansion problems in the design of equipment which the piping serves, i.e., the boilers, turbines, heat exchangers, process equipment, etc.

Blaw-Knox Company's power piping division, Pittsburgh, has a new method of making design computations that eliminates delays by taking advantage of the high accuracy and speed of electronic computers. With this automatic method it is possible to complete computations within a single working day. The method is available for use by consulting engineers and to companies and individuals responsible for the design of power piping systems.

The automation of these engineering problems was accomplished in an 18-month joint research project with Arthur D. Little, Inc. In this instance, since the existing "classical approach" was not well adapted to these machines, basic principles of stress calculations were re-examined.

Although not the first to use an electronic computer for this purpose, the method, known as the "6 by 6" Flexibility Matrix Method, is an outstanding improvement because of the simplicity, speed, and the high accuracy that are obtained with it.

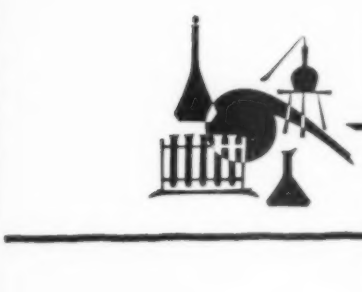
The data that are fed into the machine consist only of dimensions that can be taken easily from an isometric drawing of the piping system, and a few physical properties of the pipe material. These data are first tabulated on simple forms from which the figures can be fed readily into a suitable input medium such as magnetic tape. The actual machine part of the computation takes less than an hour. The total time required includes that for putting the data on tape, checking the accuracy of a printed transcription, putting the tape through the computer, and for a machine transcription of the computed results that are obtained on output tape, into orderly tabular figures.

Piping system complexity is unlimited. Any number of anchors and restraints can be included. Out-of-plane bends as well as restrains are routine. The number of free ends and junctions has no effect on the accuracy or efficiency of machine analysis. Floating headers, with the resulting calculations naturally proceeding back through the superheater tubes to the boiler restraints, are taken into account. Also, all of these factors can be taken into account in looped systems in which stream flow passes from a single pipe into two pipes and then into a single pipe again.

Only mathematicians can appreciate the fact that a serious accuracy limitation of the former "classical approach" which requires "inversion of larger matrices" was overcome by introducing a method that employs 6 by 6 matrices throughout. However, one can appreciate that one important advantage arising from the new method is that in the process of designing a piping system, when it is necessary to change one component, the additional calculation is confined to this member instead of requiring, as before, a complete re-calculation of the whole system.

The importance of the new method from the standpoint of cost is largely to be derived from time savings in completing the design of a piping system and thereby, the power plant or processing plant in which it will be used.

*Condensed from an article by M. G. Van Voorhis, discussing the application of computers to engineering calculations.



Analytical Methods

To Determine Total Sulfur Rapidly, in Volatile Hydrocarbons

Complete, accurate sulfur test made in 30 to 35 minutes

P. J. Sullivan
Chief Chemist,
Bay Refining Corporation

ABOUT a year ago it was necessary for our control laboratory to run the total sulfur on 35 Hempel gasolines of 375 end point. Ordinarily this should have been done in accordance with ASTM designation 090-55T,[11] Sulfur in Petroleum Products by Lamp Gravimetric Method.[11] This would require more time than the deadline for results on the gasolines would allow. Due to this urgency the following method was developed and has given results that are well within the tolerances of ASTM 090-55T. In addition, it has the advantage that a complete sulfur determination can be made in from 30 to 35 minutes.

Apparatus Required

Resistance type furnace capable of maintaining 2400F with provisions for a combustion tube of 1-in. inside diameter for 17½ in., reduced to an outlet size of ⅛ in. inside diameter for 9½ in.

Automatic or manual sulfur titrator.

Combustion boats 3¾ in. by ½ in. by 7/16 in.

Compressed oxygen and metering device capable of supplying one liter per minute.

Boat pusher in a rubber stopper equipped with a packing gland and T connection for oxygen inlet to the combustion tube.

50 cc narrow mouth Erlenmeyer flasks.

Pan balance accurate to 0.01 gram.

Solutions Required

Starch solution — 2.4 grams Lintner's starch in 7 ml of distilled water made into a paste, added to 500 cc boiling water. Cool, add 4 grams potassium iodide and dilute to 2 liters. Fifteen cc of this solution is used in the absorber on each determination.

Hydrochloric acid solution — 40 cc concentrated HCl to 1960 cc distilled water. Forty-five cc of this solution are mixed with the 15 cc of the starch solution each time in the absorber.

Potassium iodate—titratant—.2225 grams potassium iodate made up to 1 liter. One cc of this solution is equivalent to .001 grams of sulfur on the basis of a 1 gram sample. This solution is to be accurately standardized against a known sulfur.

Mineral oil USP grade—extra heavy with a specific gravity of .885 to .890. Check a .1000 gram sample for sulfur.

Procedure

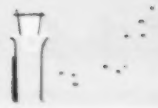
Chill the sample and mineral oil to 35F-40F. Take the tare weight of a 50 cc Erlenmeyer flask and weigh 10 grams of the chilled mineral oil into it, using the pan balance. Now weigh into this same flask 10 grams of the chilled sample. Place a cork stopper in the Erlenmeyer and gently swirl the mixture making sure it does not touch the stopper which should not extend into the flask any more than ⅛ in. Chill the mix in ice water until ready to weigh sample.

If two or three drops of mineral oil only are distributed at equal intervals along the combustion boat previous to getting the tare weight, it will offset the rapid absorption of the sample and thus minimize evaporation losses. Into this previously tared combustion boat, weigh out .2000 grams of the above mix, the sample weight in this case is .1000 grams. Weighing with a minimum of time is easily accomplished with a fine tipped medicine dropper. Room temperature preferably should be about 70F and free from draft.

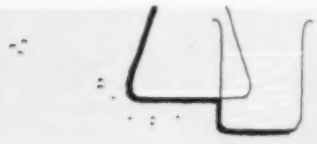
Bed the combustion boat level full with a 90 mesh Alundum to retard combustion. Rapidly transfer the boat to the combustion tube and start the oxygen flow at one liter per minute. Wait two minutes for the boat to pick up a little temperature and permit the more volatile fractions to escape, then advance the boat no faster than ½ in. per minute for the next seven minutes. Continue advancing the boat until the 2400F zone is reached.

Since 1 cc of the iodate solution is equivalent to .001 grams of sulfur based on a 1 gram sample and you have used a .1000 gram sample, the percentage reading is apparent on the burette merely by shifting the decimal point after using any solution correction factor necessary.

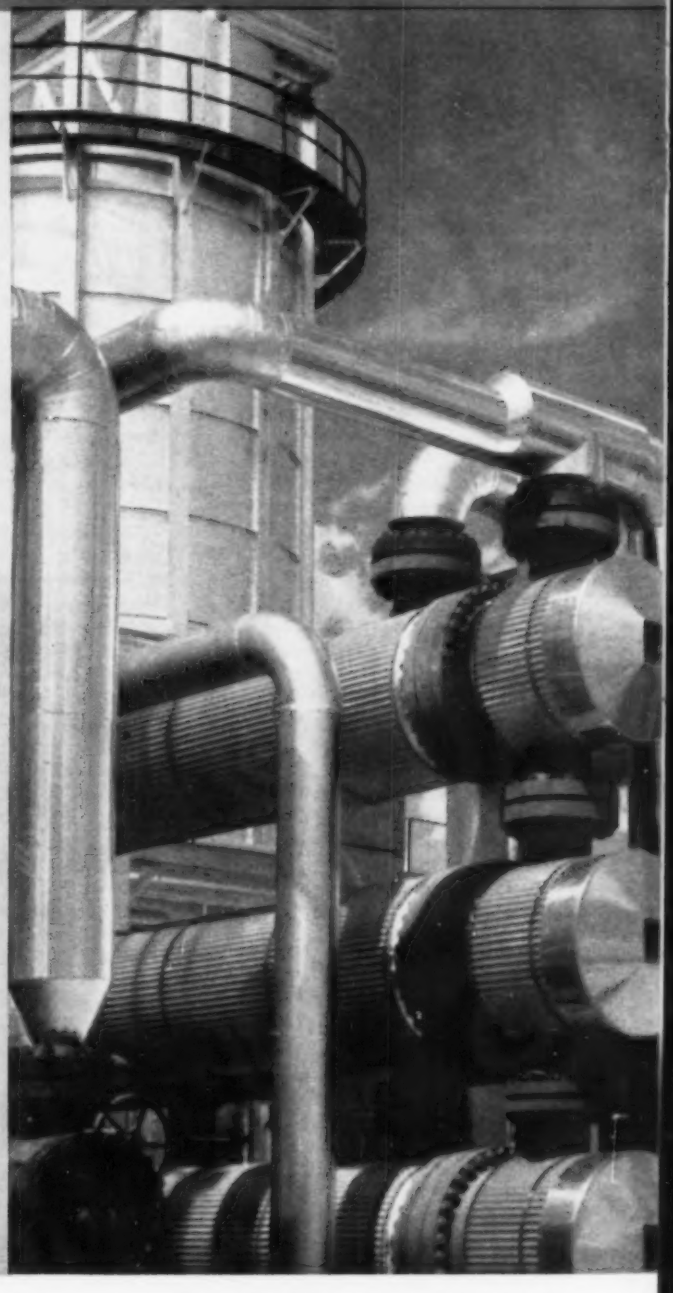
We have used this method for a year in running total sulfur on straight run and leaded gasolines, jet fuels, and naphthas. On a 375 end point gasoline standardized at .500 per cent sulfur by a highly reputable laboratory and sent to us for test we obtained .502 per cent by this method. ★ ★ ★



this development of a research idea . . .



helps make



This picture shows the business end of a bright idea for gasolines. It is the heart of the UOP Rexforming process, a new development in petroleum refining that produces automotive gasolines with the industry's highest octane ratings.

The idea was born in our research laboratories. The equipment necessary to make the process commercially practical was developed by UOP design and process engineers.

A lot of scientists, technicians and engineers spared neither brains nor labor in bringing this idea to its successful practical application. And back of it all was the basic purpose of making the gasolines you sell meet today's demand for more efficient motor fuels and perfecting the methods to make its manufacture efficient and economical.

Not only at UOP, but throughout the petroleum industry "men of science" are constantly working to provide the "men who sell" with more marketable products from petroleum. They, too, have an important part in the great economic process of creating demand by making supply more salable.

UOP has prepared an interesting booklet on "How Men of Science Help You Sell". We'll be glad to send you a copy on request.

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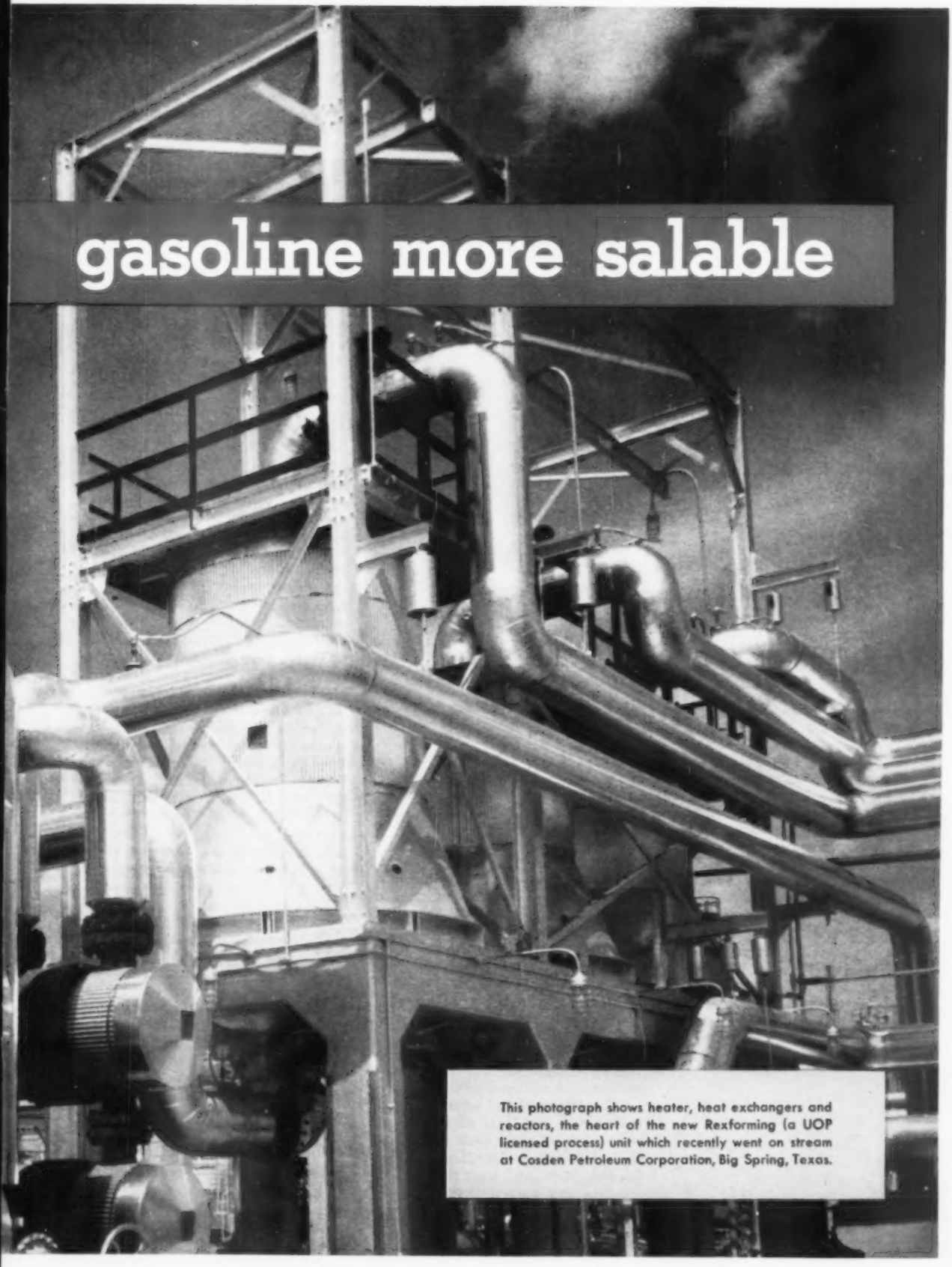
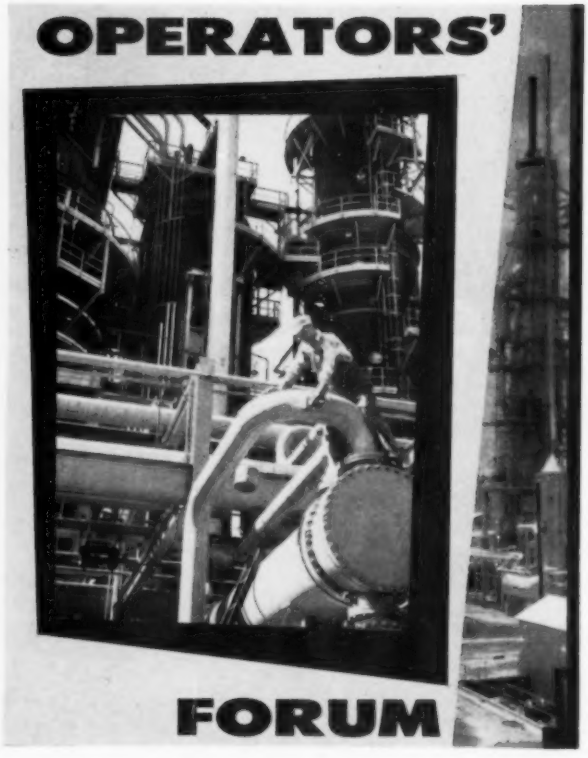


This photograph shows heater, heat exchangers and reactors, the heart of the new Rexforming (a UOP licensed process) unit which recently went on stream at Cosden Petroleum Corporation, Big Spring, Texas.



MATERIALS TO COMBAT CORROSION

Q What two metals proved best in heat exchangers, condensers, etc., to combat corrosion caused by (a) Salt (sodium chloride) or salt water; (b) Hydrogen sulfide; (c) Petroleum (organic) acids; (d) Electrolytic action?

S. M. E.

A Let us distinguish between heat exchangers on the one hand, and coolers and condensers on the other. In the heat exchanger a hot hydrocarbon fluid gives up its heat to a colder hydrocarbon fluid; while in the condenser or the cooler, heat recovered from the hot hydrocarbon fluid is taken up by cooling water.

In general, most of the exchangers built are of carbon steel construction. Since cooling water is routed through the tubes of shell-and-tube condensers and coolers, inhibited admiralty tubes and naval-rolled-brass tubesheets are used while all other parts are carbon steel. For high temperature and high pressure operation, such as occurs in catalytic reforming, alloy steels are employed which range from low-chrome upward to stainless depending on the operating temperature. Recently aluminum has been finding increased application because of its suitability in many kinds of service and its low cost (approximately the same as steel).

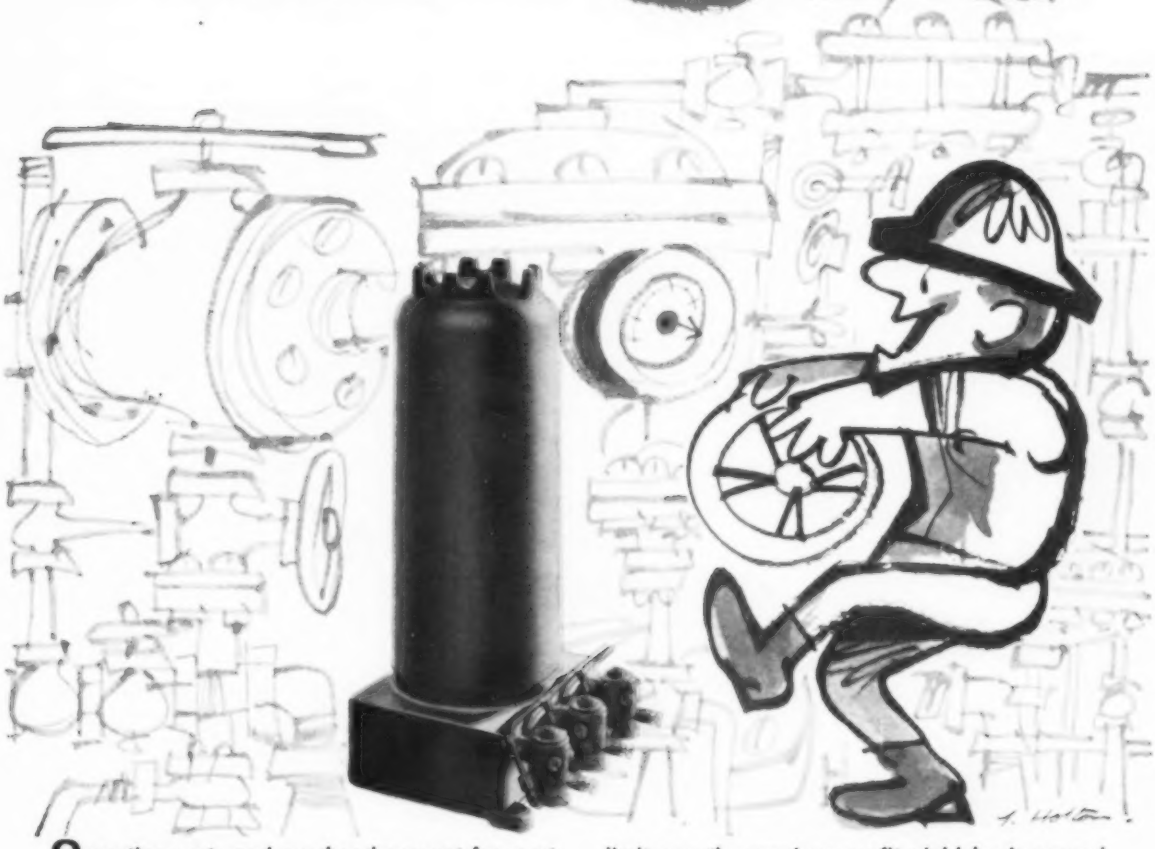
Corrosion and erosion are complex conditions that vary considerably, even within, the same refinery. Instances have occurred where heat-transfer equipment has worn out a few weeks after its installation. Such extreme conditions demand that the metal be protected against the corrosive action or that another metal be used which resists corrosion. Metals are protected by making them extra heavy to allow for corrosion, by lining or spraying with a more resistant material, by cathodic protection, by employing inhibitors which cover and protect the vulnerable surface, or by neutralizing a corrosive substance by reaction with a suitable chemical.

(a) **Cooling Water.** It is the practice in some chemical plants to use all-steel units for coolers and condensers where treated cooling tower water is recirculated. In shell-and-tube equipment the tube-side fluid is in contact with tubes, tubesheets, channel cover and floating-head cover; while the shell-side fluid is in contact with shell and shell cover. Some of the troubles encountered in water-cooled units will be mentioned. Admiralty tubing has undergone dezincification but this condition has been mitigated by the addition of small amounts of arsenic, antimony, or phosphorus as inhibitor. Use of steel tubesheets with admiralty tubing where brackish water was coolant resulted in severe wear of the tubesheet from galvanic action. The use of naval-rolled-brass tubesheets eliminates this difficulty. Ordinarily it is sufficient to make the channel, channel cover and floating-head cover of carbon steel and add ⅛-in. or ¼-in. corrosion allowance. However, salt water eats up steel. Cast iron, which is resistant and of the same magnitude of cost, is preferred. Another possibility is to fabricate these parts of monel or bronze, but since these alloys cost considerably more they are seldom used. Alternatively, the inside of those parts contacting cooling water may be sprayed by a protective coating of zinc. The effect of galvanic action has been observed at the gasket surface which is a particularly vulnerable spot, because a smooth metal surface is needed at both sides of the gasket to insure a tight joint. A method of combatting this is to weld a ⅛-in. thick ring of monel to the channel flange at the gasket-bearing surface.

(b) **Hydrogen sulfide** gas is encountered in overhead condensers that are water-cooled. Ordinarily, water-

Continuous stream analysis . . . for optimum process yields.

The profit is in the last few pounds



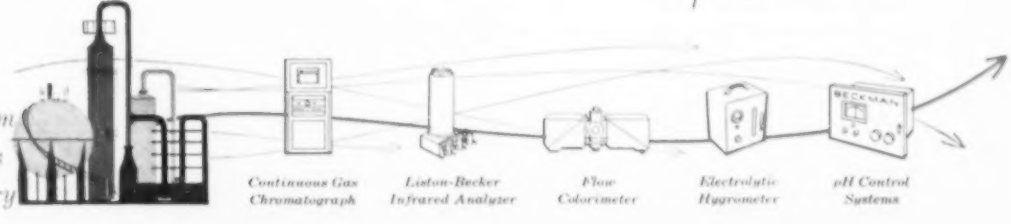
Operating costs and overhead account for most of the pounds, gallons or tons of production. The profit is in the last few percentage points of yield. Only by running the equipment right up to the limit can the precious profit yield be increased. Beckman Infrared Gas Analyzers provide the operator with the continuous, precise process information required for the extra pounds that count.

The Beckman Model 21 Infrared Gas Analyzer is a rugged industrial instrument for the monitoring of plant streams, liquid or gas. It is a positive, non-dispersive instrument of service-proved superiority in reliability and accuracy. It can be coupled with a standard recorder or with a recorder-controller for automatic process control. Commercial applications include continuous analysis for the purity of ethylene (90-100% range) and butadiene (95-100% range); the measurement of methane and ethane in ethylene; CO and CO_2 in hydrocarbon streams and ammonia synthesis gas; unreacted CH_4 in natural gas reforming.

Sensitivity of the Model 21 is 0.1 ppm; accuracy, ±1% of scale. Maximum sensitivity drift is 1% of full scale in 24 hours; maximum zero drift, 1% of full scale in 8 hours. The analyzer unit, in explosion-proof housing, can be mounted vertically or horizontally, convenient to the stream – up to 600 feet from the control panel-amplifier. For full details, write for Data File P-4-26.

Beckman® / *Process Instruments*
Beckman Instruments, Inc.
Fullerton, California

Stream Analyzers for Industry



cooled exchangers employ admiralty tubes and naval-rolled-brass tubesheets but these alloys do not stand up against H_2S. Here a bimetallic tube, made of steel outside and admiralty inside, suits the purpose. Likewise, the tubesheets are steel on the shell side with naval-rolled-brass cladding on the tube side. Aluminum is resistant to moist H_2S. Vapors containing H_2S and water vapor severely attack the tube bundle just below the shell inlet nozzle where a metal plate covers the tubes to protect them against vapor impingement. Here the attack is a combination of corrosion and erosion.

(c) **Acid corrosion** of refinery equipment is caused by hydrochloric and sulfuric acids. Hydrochloric acid is produced during distillation by hydrolysis of magnesium and calcium chlorides contained in the crude. Sulfuric acid may be formed, when H_2S and water vapor are present, by oxidation to SO_3 or some may remain after sulfuric acid treatment for the removal of unsaturates. Free CO_2 gas is evolved from crude oils on heating. If petroleum acids, such as naphthenic and cresylic, are present they are not considered to be as corrosive as the inorganic acids. Since corrosion caused by acid gases is most severe they are sometimes neutralized by injecting ammonia into the condensing system or by introducing a low-viscosity, organic inhibitor such as the amine types which is adsorbed on iron and iron oxide surfaces as a protective monomolecular film.

(d) **Electrolytic Action.** When water containing an appreciable amount of dissolved salts flows through the tubes of a cooler or condenser there are two different metals, copper (or its alloys) and steel, immersed in an electrolyte. Under these conditions steel goes into solution and will dissolve or corrode as a consequence of this galvanic or electrolytic action. To circumvent this effect zinc or magnesium sacrificial plates are inserted in the channel to replace steel as the anode which is galvanically coupled with copper, and they dissolve while the steel is not attacked. Sometimes a zinc stick is screwed into the channel of a cooler to serve as a sacrificial anode. The inner end of the stick is hollow so that, before it becomes spent, a hole wears through where a "tell-tale" leak of water serves notice that a replacement anode is needed. Sacrificial anodes, in the form of flat magnesium slabs, are bolted to a channel cover; they must be renewed periodically. Sacrificial anodes also have been used in submerged condenser boxes. Aluminum tubes are clad with a sacrificial aluminum alloy layer to resist corrosion (Alclad.)

D. A. Donohue

Operators Forum

"COLORLESS" ASPHALTS

Q "I would like to have some more information about colorless bitumens of which I read in the article "Refining Methods for Waxes, Asphalts, Greases and Compounded Oils" (The Petroleum Engineer, June 1956, page C-20.)

This activity could be very interesting as nothing has been developed in this regard in Italy up to this time.

If a good market for colorless bitumens already exists in the States, I think the same could be done for Italy, provided it is based on a real technical and commercial experience."

P. M.

A The name "colorless asphalt" is confusing because it implies that the product has a water-white or at least a light straw-yellow color. Actually the "colorless asphalt" is very dark although it is not as black as the conventional asphalt. "Colorless asphalt" finds application in the preparation of special materials which contain inorganic pigments like ochre or red lead. The resulting colored asphalts are useful for certain specific purposes, for instance, for making directional signs on paved roads.

Much work was done in search for a method which would produce an asphalt of a water-white color. Success of this work depended on the correctness of various theories regarding the origin of coloring matter in petroleum and related materials. According to one theory all petroleum hydrocarbons are colorless and the dark color of the oil or asphalt is due to the presence of very small quantities of impurities which can be removed without affecting other properties of the product. Another theory assumes that many hydrocarbons in petroleum are colored substances and that the intensity of their coloration increases with their boiling point. This does not exclude the possibility that some of the heavy hydrocarbons might be colorless, but presumes that their percentage is small. If the first theory is correct, a water-white asphalt can be made by subtractive refining. The second theory discounts this possibility. Production of colorless asphalt from petroleum is attractive commercially as such a product may be sold in competition with the expensive synthetic resins. This explains the reason why many petroleum companies were engaged in this research.

The results of these investigations showed that no known chemical or solvent is capable of producing a colorless asphalt. However, the color of the asphalt could be lightened somewhat by the removal of heavy colloidal materials suspended in the asphalt. Removal of these materials resulted in the lowering of the softening point of the product. The lighter was the color of the recovered material, the lower was its softening point and the less was the yield.

The work done by the writer on an asphaltic residue from a Colombian crude indicated that the color of the product was a direct function of its softening point irrespective of the nature of the decolorizing agent employed. These decolorizing agents included a large variety of substances, such as mineral and organic acids, chlorides of metals, solvents, hydrogen and others. However, this color-softening relationship varies with the nature of the crude oil which may be expected from other observations. For instance, Trinidad (natural) asphalt is known for its light color as compared to other asphalts.

"Colorless asphalt" is thus not a distinct material, but the name may be arbitrarily applied to any asphalt which is lighter in color than other asphalts, and is suitable for incorporating pigments into it. Refining of asphalt in propane solution with sulfuric acid can be used for improving the asphalt color. The manufacture of colored from "colorless" asphalts is a blending problem.

V. A. Kalichevsky

HOW TO DOUBLE REFINERY RUNNING-TIME BY KEEPING CORROSION DOWN

After eight months' operation, with KONTOL on the job, an eastern refinery reported the following: corrosion in the overhead condenser was not even measurable . . . there was a 33⅓% increase in the heat transfer coefficient . . . tower tray corrosion was completely eliminated. And because of KONTOL's detergent action, running time in this typical depropanizer application was doubled.

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RR-57-1

Chemicals from Petroleum

From a fledgling infant in 1945, petrochemicals have become one of our largest chemical industries

Chapter XV

V. A. Kalichevsky
Consulting Chemical Engineer

MANUFACTURE of chemicals from petroleum is a rapidly expanding industry. These chemicals are given a general name "petrochemicals" *(petroleum chemicals)*. The name is often misused and applied to any substance produced by the petroleum industry except the basic products. Some of these substances, like phenols or naphthenic acids, are by-products recovered in the course of refining and are not petrochemicals. The term "petrochemicals" should be confined to chemicals *made* from petroleum and related materials, like natural gas.

The same chemicals can be made from a variety of raw materials. For instance, alcohol can be prepared by fermentation of farm products and by oxidation of hydrocarbons. Benzene is a product common both to coal-tar and petroleum industries. With the modern developments in organic chemistry, any substance containing carbon and hydrogen can be obtained, at least in the laboratory, from another substance made of the same elements. The molecules are split into atoms and the atoms recombined into the new molecules. This is not done commercially because it is cheaper to use the readily available materials having molecules which are partially built up in the desired direction than to start from the atoms. The term "petrochemicals" should be reserved to chemicals which can be made from petroleum on competitive basis.

Beginning of Petroleum Chemistry

Petroleum is a prolific source of hydrocarbon materials. Much work has been done for years by the scientific and industrial laboratories to utilize it in the manufacture of organic chemicals. Many obstacles had to be overcome before the results of these efforts were realized.

Wonderful achievements in the field of the chemistry of coal-tar products served as a great inducement to petroleum chemists in their ambitious studies. Their work was handicapped by the presence of an endless variety of hydrocarbons in crude petroleum that had to be isolated before they could be used in the organic reactions. These difficulties are not encountered with coal-tar which contains large quantities of individual hydrocarbons such as benzene, toluene, xylenes, naphthalene, and anthracene. These hydrocarbons boil far apart and can be separated from one another by distillation. The immortal work of William H. Perkins, the founder of coal-tar chemistry, was made possible by the ease with which he was able to obtain large volumes of these hydrocarbons in a pure state.

For the same reason, the development of the chemistry of benzene (aromatic) hydrocarbons advanced infinitely faster than that of petroleum (aliphatic) hydrocarbons. Many new and important reactions involving the latter have recently been discovered, and a number of errors and fallacies have been unearthed in the firmly established conceptions and theories that were based on insufficient experimental evidence and incorrect deductions. For instance, the name "paraffins" for the saturated open-chain hydrocarbons originates from Latin "parum affinis," that is "small affinity." It was attached to them because these hydrocarbons are not responsive to the common strong chemical reagents like sulfuric and nitric acid, alkalies and oxidizing agents. This discouraged many chemists from working with the paraffins when they could apply their talents to the synthesis of new substances from the reactive aromatic hydrocarbons and, at a later date, from the unsaturated compounds. Reactions of isomerization, alkylation or cyclization to which the paraffin hydrocarbons are susceptible

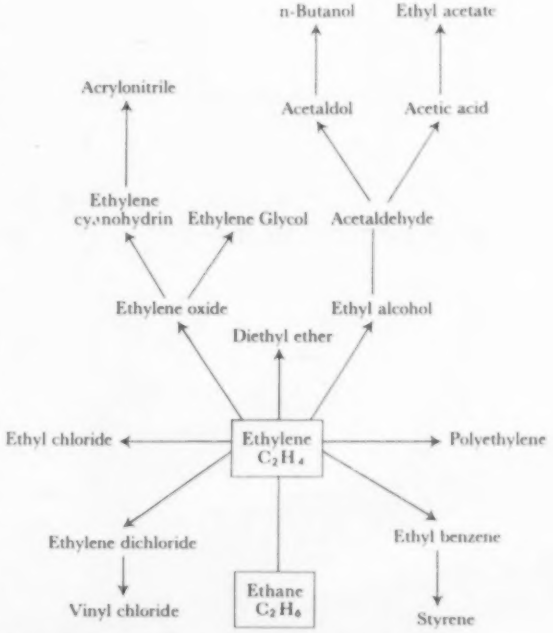
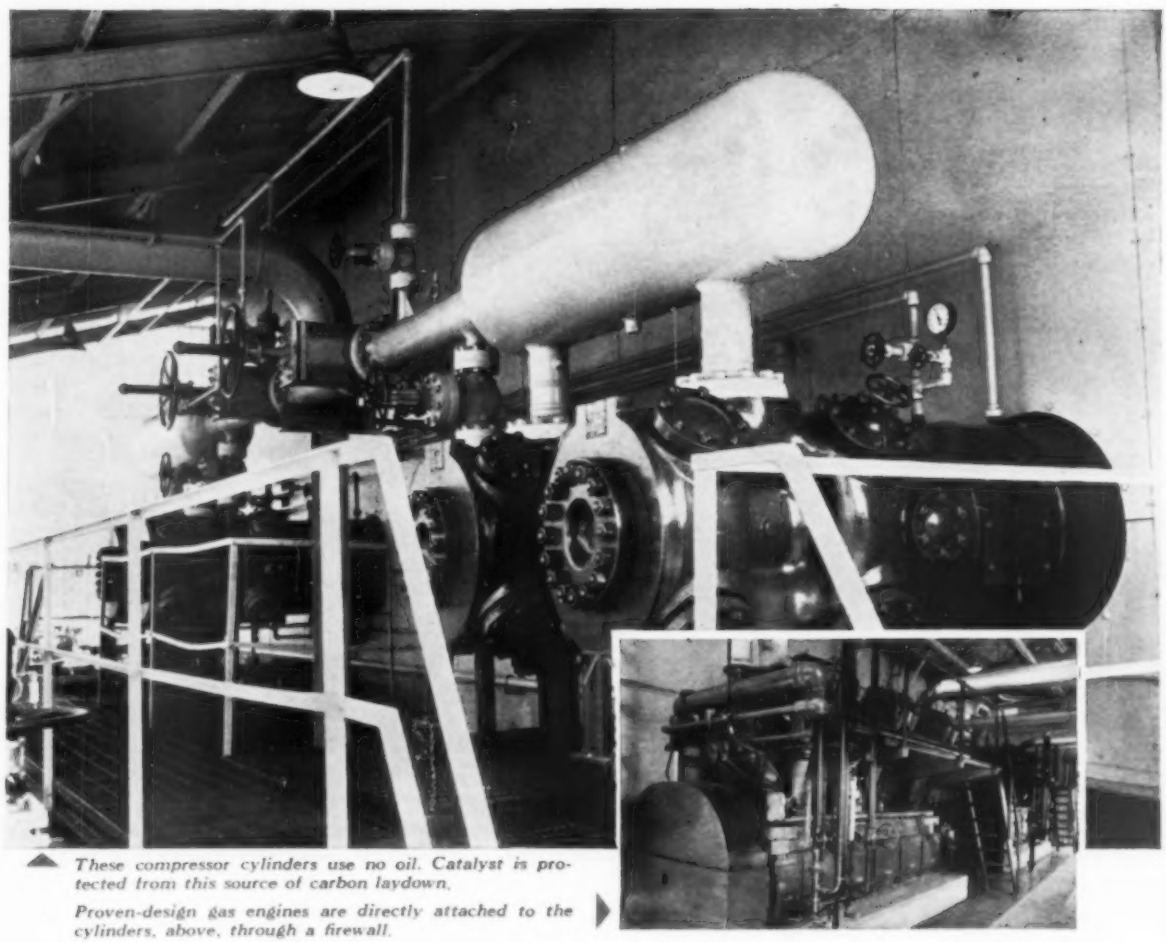


FIG. 1. Only a small percentage of the chemicals that are made from ethane (C_2H_6) are shown here. families and classes.

CUT ALONG THIS LINE FOR YOUR PERSONAL REFERENCE FILE.



These compressor cylinders use no oil. Catalyst is protected from this source of carbon laydown.

Proven-design gas engines are directly attached to the cylinders, above, through a firewall.

CATALYST LASTS LONGER

with NL compressor cylinders

No oil to carry over in the recycle gas

One feature of the Platforming process, developed and designed by Universal Oil Products Company, is long catalyst life without regeneration. That means a low catalyst cost per barrel of high-octane gasoline. That's why Skelly Oil Company's Platformer at El Dorado, Kansas, uses Ingersoll-Rand compressors with 'NL' non-lubricated cylinders.

In NL cylinders there is no oil to carry over in the recycle gas into the catalyst-packed reactor. Presence of oil would result in carbon laydown (coating which renders catalyst inactive). Oil also causes excessive hydrocracking and formation of undesirable polymers.

The pistons of NL cylinders are supported by graphitic carbon rings sliding in a mirror-smooth bore. Operation is dependable without oil lubrication.

Cylinders are connected to the gas-engine frame by special two-compartment distance pieces that are sealed and vented to allow safe handling of the hydrogen-laden gas.

The two 660-hp KVG compressors handle a total of 73 million cubic feet of gas a day, boosting pressure from 450 psi to 610 psi. Using available gas, their four-cycle, V-angle engines produce low-cost power at all loads.

Ask your I-R representative for complete information on Ingersoll-Rand gas-engine compressors and non-lubricated compressor cylinders. Obviously standard oil-lubricated compressors should be used wherever possible to reduce first cost and maintenance.

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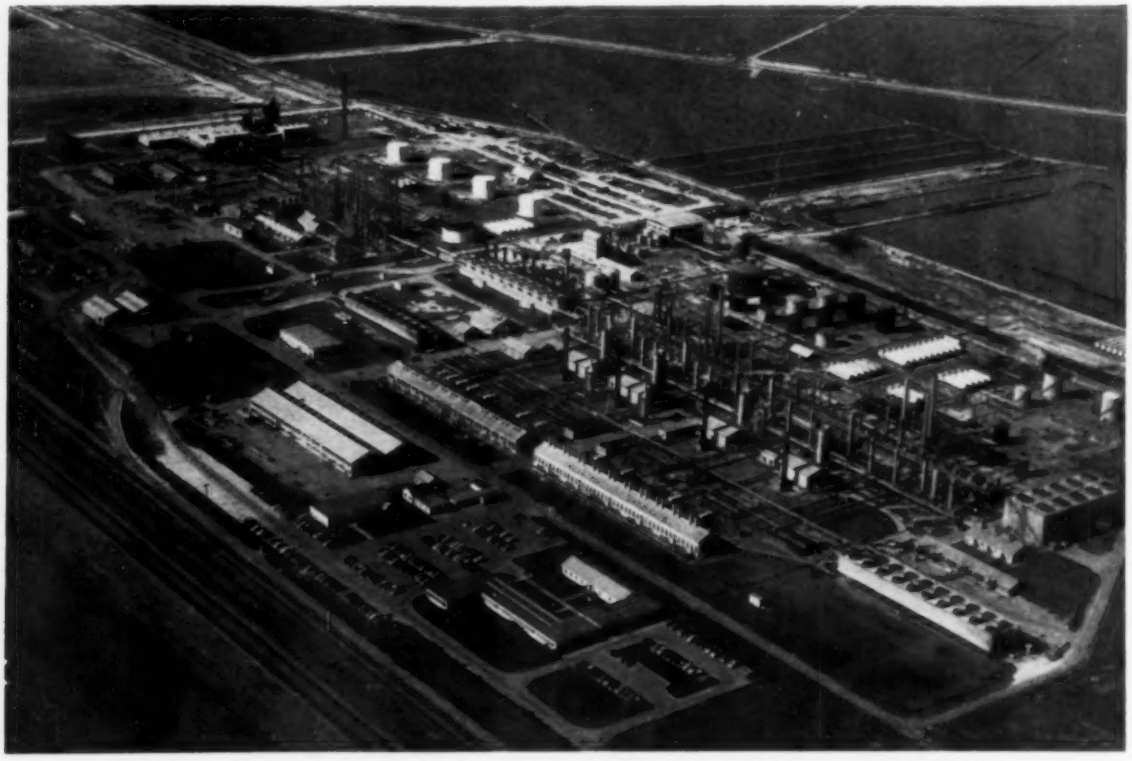

FIG. 2. Another of the outstanding pioneers — Celanese Corporation's Bishop, Texas hydrocarbon, oxidation plants, where the multitudinous numbers of oxidation products are made, separated, and finished.

and which form the basis for many organic syntheses remained undiscovered for many years.

Like the chemistry of coal-tar products, that of petroleum hydrocarbons began its development with the study of the low-boiling compounds. They were separated in large quantities by the improved methods of fractional distillation. The progress in these studies paralleled the isolation of other substances from petroleum, such as oxygen and nitrogen compounds and metals. With the increase in boiling point, the variety of substances present in petroleum increases at a very rapid rate. One hydrocarbon containing a single carbon atom, that is methane, is known. Seventy-five isomers of a paraffin hydrocarbon having 10 carbon atoms may exist. This figure is raised to 366,319 isomers for a paraffin hydrocarbon having 20 carbon atoms and to 62,491,178,805,831 isomers for a paraffin hydrocarbon having 40 carbon atoms in the molecule. The number of possible isomers is greater for the unsaturated hydrocarbons than for the saturated ones. The first olefin, ethylene, has two carbon atoms and no isomers. Olefins containing 10 and 20 carbon atoms have 377 and 4,224,-993 isomers, respectively. Alcohols, mercaptans, amines of the simplest type have 95,991,365,288 isomers if their molecule has 30 carbon atoms. These astronomical figures are beyond understanding of any individual.

This huge number of hydrocarbons including their isomers places definite limitations both on the ease of their isolation and on the available quantities of the individual substances. For these reasons petroleum chemistry is limited to the few low-boiling hydrocarbons.

Another factor contributing to the slow progress of the petrochemical industry is the organization of the marketing and distributing facilities of oil companies. These facilities are best suited for handling products in bulk quantities. New service branches and specially trained personnel must be provided for dealing in synthetic materials. This is just as important as to have research and development represented by a separate organizational unit and not as an addition to a refinery or sales department. The managerial principles are radically different in handling these organizations and an excellent manager in one of these branches of the industry is a complete failure in another.

Facilities of the petroleum industry are best suited for handling products in bulk quantities, statistically and not individually. New service branches and specially trained personnel had to be provided for dealing in synthetic materials and the opposition of the "old guard" had to be overcome. No immediate profit could be expected from such enterprises, and much time was needed to pay off the initial investment. In addition, the income derived from selling chemicals was, for the time being, a negligible addition to profits accruing from the sale of huge volumes of normal petroleum products. Possibilities of expanding the sale of petrochemicals in the future was overlooked. Real benefits to be realized from these new undertakings was postponed by some companies indefinitely to their detriment.

Chemical companies were the first to use petroleum hydrocarbons as raw materials for synthesizing chemicals, that is for making them artificially. These hydrocarbons were not necessarily obtained from petroleum sources. The petroleum industry has been able to supply them at a reasonable cost only recently. Chemical synthesis carried on by the explorers was difficult and uneconomical. However, at the present time the manufacture of chemicals from petroleum is on a well established basis and has excellent possiblities for the future. A number of petroleum companies are actively engaged in supplying the market with chemicals and in developing new sources of income from the full utilization of their raw materials. All organic

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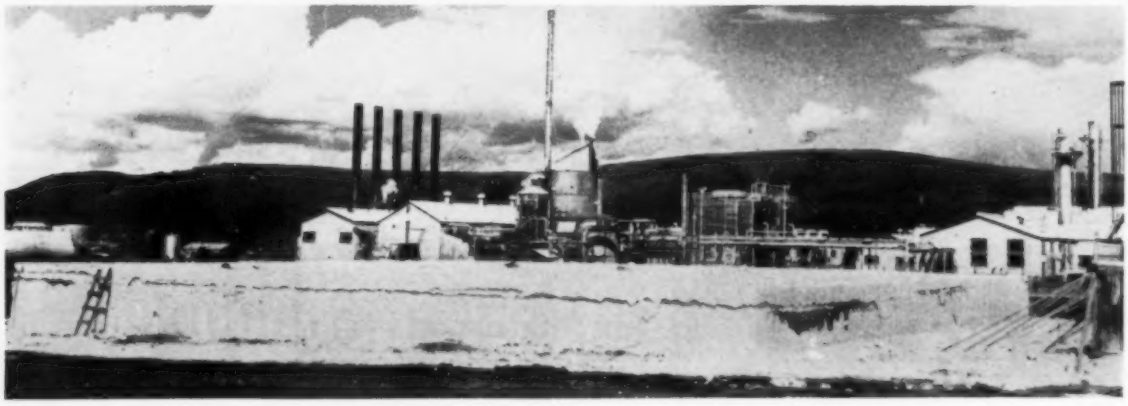

FIG. 3. A "mountain" of elemental sulfur, recovered from natural gas; this "block" is said to weigh about 2400 tons (4,800,000 lb). (Shell, Alberta.)

chemicals can be made, using crude oil as the base.

The expansion of the petrochemical industry during the recent years was spectacular. For instance, in 1940, the volume of butane and propane used in the manufacture of chemicals was 825,000 bbl. This volume increased to 20,000,000 bbl in 1950 and to over 32,000,000 bbl in 1953. This is a forty-fold increase over a brief period of 13 years.

The absolute quantity of petroleum used by the petrochemical industry is large but the relative quantity is small. Only about three quarters of one per cent of petroleum production is utilized for this purpose. However, the profits are much larger than those derived from using petroleum for fuel and lubrication. The high price of lubricating oils is due not to their crude oil component but to the chemicals that must be added to them and make them workable in modern machinery. Reduced income from refinery operations influenced the progressive oil companies to produce chemicals for maintaining reasonable returns on the capital investment.

Basic Reactions of Petroleum Hydrocarbons

Reactions of hydrocarbons found or prepared from petroleum and their conversion to other organic substances is the full scope of organic chemistry which is defined as the chemistry of organic compounds. Every organic substance can be made from petroleum, the source of carbon and hydrogen, but this is not always economical. The present discussion is limited to the industrially important reactions of the paraffin hydrocarbons. The products of these reactions are occasionally useful as they are produced. Mostly they are intermediate materials required for the manufacture of ultimate products.

The reactions of paraffin hydrocarbons are of two basic types. Some of the reactions involve only the hydrocarbon molecules, while others are the result of interaction of the hydrocarbon molecules with an outside substance. In the first instance a reactive hydrocarbon is formed from a paraffin hydrocarbon, in the other new reactive atoms or groups of atoms are introduced into the molecule of the paraffin hydrocarbon. In either case the substances formed offer greater possiblities for further chemical transformations than the original hydrocarbon.

Reactions of Paraffin Hydrocarbons in the Absence of Chemicals

These reactions include dehydrogenation, cracking, cyclization (aromatization), and isomerization. For promoting these reactions the paraffin hydrocarbons are exposed to temperature and pressure conditions at which they become unstable and change their structure. The presence of catalysts is often desirable for speeding up these changes. Most of these reactions occur in processing petroleum through the refinery and were described in Chapters 9, 10, and 11. They are summarized below because they are applicable to pure hydrocarbons.

Dehydrogenation

Dehydrogenation is mild cracking. It results in splitting of hydrogen atoms from the hydrocarbon molecules without breaking the bonds between the carbon atoms. This occurs because the unsaturated hydrocarbons are more stable at high temperatures than the saturated hydrocarbons. For instance, ethane forms ethylene and ethylene changes to acetylene by exposing them to progressively higher temperatures. The course of these reactions is often obscured by the side reactions but may be illustrated as follows:

1. C_2H_6 (Ethane) = C_2H_4 (Ethylene) + H_2 (Hydrogen)

This reaction is utilized commercially in the manufacture of ethylene.

2. C_2H_4 (Ethylene) = C_2H_2 (Acetylene) + H_2 (Hydrogen)

This reaction is accompanied by many side-reactions and is not employed in the manufacture of acetylene which can be prepared easily by other methods.

3. C_2H_2 (Acetylene) = $2C$ (Carbon) + H_2 (Hydrogen)

This decomposition takes place at extremely high temperatures or under the influence of electric arc. It is of indirect commercial interest because acetylene is, apparently, an intermediate product in the manufacture of hydrogen by cracking methane.

Dehydrogenation reactions are reversible, that is in the presence of hydrogen and under favorable temperature and pressure conditions carbon will produce acetylene, acetylene will produce ethylene, and ethylene will produce ethane.

Cracking

Cracking involves splitting of the bond between the carbon atoms which results in the formation of two or more smaller molecules from a large one. The smaller molecules are of saturated and unsaturated nature. For instance:

C_6H_{14} (Hexane) = C_3H_8 (Propane) + C_3H_6 (Propylene)

These reactions are basic in the thermal cracking proc-

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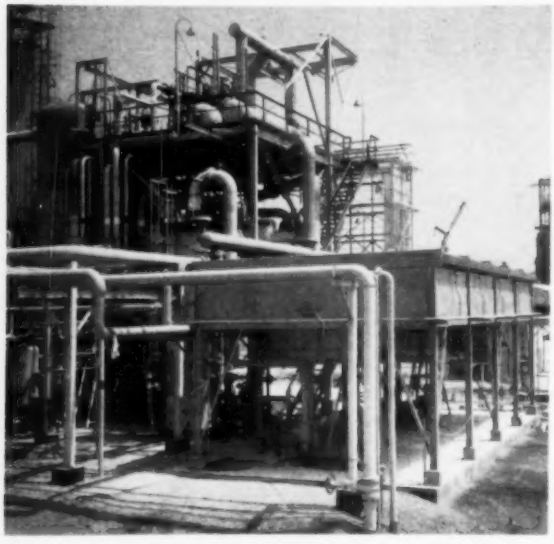

FIG. 4. Synthesis of ammonia from hydrocarbons and the nitrogen of the atmosphere is one of the greatest fields in the petrochemical industry. In this plant (Shell) these air precoolers provide additional cooling capacity for the plant's urea (ammonia derivative) unit installed recently.

esses. They are complicated by many side-reactions. As a result a complex mixture of hydrocarbons of widely different boiling points, which may be lower and higher than the boiling point of the original hydrocarbon, is obtained.

Isomerization

This reaction involves rearrangement of carbon and hydrogen atoms within a hydrocarbon molecule but otherwise leaves the molecule intact. Isomerization processes are used commercially. One of them produces isobutane from normal butane.

$$\underset{\text{Normal butane}}{n\text{—}C_4H_{10}} = \underset{\text{Isobutane}}{iso\text{—}C_4H_{10}}$$

Cyclization

Cyclization is a dehydrogenation reaction accompanied by formation of ring hydrocarbons from the open-chain hydrocarbons. It is an important commercial reaction involved in the manufacture of benzene and other aromatic hydrocarbons from petroleum and in reforming.

$$\underset{\text{Normal hexane}}{C_6H_{14}} = \underset{\text{Benzene}}{C_6H_6} + \underset{\text{Hydrogen}}{3H_2}$$

Reactions of Paraffin Hydrocarbons in the Presence of Chemicals

Alkylation, oxidation, halogenation, nitration, and sulfurization reactions belong to this group. Sulfonation is not a reaction typical for paraffin hydrocarbons, but is included in this description because it is basic for benzene which is made in large quantities from the petroleum hydrocarbons.

Alkylation

In the alkylation reactions unsaturated hydrocarbons can be classified as chemicals because of their high reactivity. Only the iso-paraffins, which are the most reactive among the paraffin hydrocarbons, can be alkylated. One of the commercially important alkylation reactions leads to the formation of neohexane from iso-butane and ethylene.

$$\underset{\text{Isobutane}}{iso\text{—}C_4H_{10}} + \underset{\text{Ethylene}}{C_2H_4} = \underset{\text{Neohexane}}{C_6H_{14}}$$

In these reactions a saturated molecule is produced. This saturated molecule is comparatively non-reactive. The products of the alkylation reactions offer little promise for further synthesis and are accomplishments in themselves.

Oxidation

Oxidation reactions are complex because oxygen is not selective in attacking the hydrogen and carbon atoms in a hydrocarbon molecule. As a result a mixture of compounds is formed which is difficult to separate into its components.

Two types of oxidation reactions can be distinguished. In one type of these reactions oxygen is added to the hydrocarbon molecule, in the other type oxygen removes hydrogen with the resulting formation of an unsaturated hydrocarbon.

Addition of oxygen to the hydrocarbon molecule may be illustrated by the following examples which refer to the formation of methyl alcohol and formaldehyde from methane:

$$\underset{\text{Methane}}{CH_4} + \underset{\text{Oxygen}}{O} = \underset{\text{Methyl alcohol}}{CH_3OH}$$

$$\underset{\text{Methane}}{CH_4} + \underset{\text{Oxygen}}{O_2} = \underset{\text{Formaldehyde}}{HCHO} + \underset{\text{Water}}{H_2O}$$

$$\underset{\text{Methyl alcohol}}{CH_3OH} + \underset{\text{Oxygen}}{O_2} = \underset{\text{Formic acid}}{HCOOH} + \underset{\text{Water}}{H_2O}$$

Removal of hydrogen from the hydrocarbon molecules is utilized commercially in the manufacture of asphalt from the petroleum residue described in Chapter 16.

In the presence of a sufficient quantity of oxygen all hydrocarbons are oxidized to carbon dioxide and water.

$$\underset{\text{Methane}}{CH_4} + \underset{\text{Oxygen}}{2O_2} = \underset{\text{Carbon dioxide}}{CO_2} + \underset{\text{Water}}{2H_2O}$$

This reaction produces the maximum quantity of heat and is important in the combustion processes.

Halogenation

Paraffin hydrocarbons react violently with chlorine, slowly with bromine and under special conditions with iodine. For example, chlorine forms the following substances on contacting with methane:

$$\underset{\text{Methane}}{CH_4} + \underset{\text{Chlorine}}{Cl_2} = \underset{\text{Methyl chloride}}{CH_3Cl} + \underset{\text{Hydrogen chloride}}{HCl}$$

$$\underset{\text{Methyl chloride}}{CH_3Cl} + \underset{\text{Chlorine}}{Cl_2} = \underset{\text{Methylene chloride}}{CH_2Cl_2} + \underset{\text{Hydrogen chloride}}{HCl}$$

$$\underset{\text{Methylene chloride}}{CH_2Cl_2} + \underset{\text{Chlorine}}{Cl_2} = \underset{\text{Chloroform}}{CHCl_3} + \underset{\text{Hydrogen chloride}}{HCl}$$

$$\underset{\text{Chloroform}}{CHCl_3} + \underset{\text{Chlorine}}{Cl_2} = \underset{\text{Carbon tetrachloride}}{CCl_4} + \underset{\text{Hydrogen chloride}}{HCl}$$

These reactions take no preference and as a result a mixture of chlorinated hydrocarbons is obtained.

Nitration

Paraffin hydrocarbons react with nitric acid or nitrogen dioxide forming nitroparaffins which find commercial uses.

$$\underset{\text{Methane}}{CH_4} + \underset{\text{Nitric acid}}{HNO_3} = \underset{\text{Nitromethane}}{CH_3NO_2} + \underset{\text{Water}}{H_2O}$$

Nitric acid is a powerful oxidizing agent. When it is applied to hydrocarbons, side-products such as oxygen compounds and unsaturated hydrocarbons are formed.

Sulfurization

Sulfur reacts with paraffin hydrocarbons with the evolution of hydrogen sulfide. Methane and sulfur produce carbon dissulfide.

$$\underset{\text{Methane}}{CH_4} + \underset{\text{Sulfur}}{4S} = \underset{\text{Carbon disulfide}}{CS_2} + \underset{\text{Hydrogen sulfide}}{2H_2S}$$

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FIG. 5. Heavy hydrocarbons are removed from the "wet" natural gas in this (National Petro-Chemicals) refrigeration plant, prior to conversion of the heavy as well as the remaining light hydrocarbons to petrochemicals and their intermediates.

Normal butane and sulfur form thiophene. This is a commercial process. The reaction leads to the formation of a cyclic molecule containing sulfur in the ring. Compounds that contain sulfur or nitrogen atoms in the ring are known as heterocyclic compounds. They are present in petroleum.

$$\underset{\text{Normal butane}}{C_4H_{10}} + \underset{\text{Sulfur}}{4S} = \underset{\text{Thiophene } (C_4H_4S)}{\begin{matrix}CH=CH\\ |\quad\ \ S\\ CH=CH\end{matrix}} + \underset{\text{Hydrogen sulfide}}{3H_2S}$$

Sulfonation

This reaction is not typical for paraffin hydrocarbons that are very stable toward sulfuric acid. Only the branched paraffin hydrocarbons enter the reaction with some ease. The reaction takes place with the aromatic and unsaturated hydrocarbons.

$$\underset{\text{Benzene}}{C_6H_6} + \underset{\text{Sulfuric acid}}{H_2SO_4} = \underset{\text{Benzene-sulfonic acid}}{C_6H_5SO_3H} + \underset{\text{Water}}{H_2O}$$

Chemical Synthesis

A molecule of an unsaturated hydrocarbon or of a hydrocarbon reacted with a chemical and containing an active atom or an active group of atoms, presents an excellent starting material for synthesis, that is for the preparation of a variety of organic compounds. Possibilities offered in this respect are for all practical purposes limitless, taxing the imagination of an organic chemist. This may be visualized by the following example showing a few chemical changes to which the molecule of pentane is susceptible.

Reacting pentane with chlorine produces amyl chloride used as solvent, for fumigating soil and other purposes. Amyl chloride reacts with ammonia yielding amines that are employed in the preparation of pharmaceuticals, dyes, insecticides, and certain rubbers. Amyl chloride also reacts with sodium hydroxide and yields amyl alcohol, a constituent of fusel oil. Amyl alcohol is a good organic solvent. It can be reacted with boron oxide, giving amyl borate, which is also a solvent and is used in paints and in rendering less inflammable photographic films made from cellulose. A number of other chemicals can be reacted with the various "derivatives," that is, substitution products of pentane, thus multiplying the number of useful substances that can be made from a single hydrocarbon. Even this presentation of the subject is much simplified and abbreviated. Many of the above reactions produce isomers having different properties. In commercial practice mixtures of isomers are often used.

The same substance can be prepared from the same original or from different starting materials. For instance, methyl alcohol can be made from methane in several ways such as by direct oxidation, already described, or by chlorinating methane, separating methyl chloride and treating it with water.

$$\underset{\text{Methyl chloride}}{CH_3Cl} + \underset{\text{Water}}{H_2O} = \underset{\text{Methyl alcohol}}{CH_3OH} + \underset{\text{Hydrogen chloride}}{HCl}$$

Methyl alcohol is also obtained in the destructive distillation of wood, that is by heating the wood, like beech, birch, or oak wood, to high temperatures in the absence of air. The decomposition products are gases, liquids, and solids. They are collected, separated into fractions and purified, if necessary. Instead of wood, vinasse can be used. Vinasse or schlempe is the residue left after molasses is fermented and ethyl alcohol formed is removed by distillation. These are only a few examples how methyl alcohol can be obtained.

In solving a manufacturing problem the organic chemist must choose the path he wants to follow in preparing the desired substance. The by-products of the reactions must be fully utilized for economic reasons. Several products are usually made in order to eliminate waste. Adoption of a major process often requires installation of auxiliary processes for manufacturing chemicals that are easily recovered as by-products or can be synthesized. Companies who try to enter the petrochemical field by manufacturing a single pharmaceutical chemical disregarding the by-products and having no general plan for future developments are doomed to failure. The commercial method for making a chemical is not necessarily the simplest or the shortest one as compared to the laboratory methods, but it must be the cheapest.

Petroleum Hydrocarbons Used in the Manufacture of Chemicals

Petroleum hydrocarbons used in the manufacture of chemicals are of the simplest type that can be easily isolated in quantities. Many of them are gases. Some of these hydrocarbons are present in the crude oil, others are obtained on cracking the heavy petroleum fractions. Distillation, adsorption, and solvent extraction are used for isolating the individual hydrocarbons or the narrow fractions. The expense involved in obtaining the desired separations determines the cost of product. This was one of the reasons why the manufacture of chemicals from petroleum had a slow start.

Methane

Methane is the only hydrocarbon that has a single carbon atom. It is found in large quantities in the oil fields but on account of its structure little has been done toward its utilization in the manufacture of chemicals. It cannot be hydrogenated as it contains only one carbon atom. It forms by far the greatest part of natural gas and is widely used as fuel.

Utilization of methane for manufacturing carbon black and hydrogen has been described. Methane is converted into acetylene by exposure to very high temperatures produced by an electric arc. Wide adoption of this process by the industry has been retarded by the high operating expense. Acetylene resulting from the process may be employed in welding, converted into benzene or acetic acid,

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and used for the preparation of a large number of other organic compounds.

Methane reacts with chlorine, but the same products can be obtained cheaper by other reactions unless the conditions are extremely favorable for the process. This happens because chlorine is expensive and in preparing the chlorinated compounds from methane some of the chlorine is wasted in the form of hydrogen chloride which is a cheap chemical. For instance, in preparing methyl chloride by reacting methane with chlorine, only half of the chlorine appears in the product. The other half is consumed in the formation of hydrogen chloride. If methyl alcohol is reacted with hydrogen chloride, however, the same product is obtained from materials the overall cost of which is lower than that of chlorine and methane.

CH_3OH	+	HCl	=	CH_3Cl	+	H_2O
Methyl alcohol		Hydrogen chloride		Methyl chloride		Water

The same considerations apply to the manufacture of chloroform and carbon tetrachloride. These two well known substances can be made more economically from chemicals other than methane.

Nitration appears to be a promising commercial reaction for methane, but economic considerations favor the use of ethane or propane. These hydrocarbons produce several nitration products that are required by the trade and nitromethane is one of them. It is obtained as a by-product in a sufficient quantity to satisfy the market demand.

Recently some progress was made in utilizing methane for the manufacture of methyl alcohol and other substances containing oxygen. But even this reaction is conducted in a round about way. Methane is used as a source of water gas, also known as blue gas. This gas is a mixture of carbon monoxide and hydrogen. It can be obtained also by interacting coal with steam. Water gas and not methane is the material used for chemical synthesis. Formaldehyde is obtained commercially not from methane but by oxidizing methyl alcohol, propane or butane. Huge quantities of formaldehyde are consumed in the preparation of synthetic resins and plastics, and as a disinfectant.

Ethane

Ethane may be utilized in the same way as methane. On oxidation it can be converted into ethyl alcohol and on chlorination it yields a number of chlorinated compounds, like ethylene dichloride which has good solvent properties and is also used in the ethyl fluid for volatilizing the lead compounds. Ethylene and not ethane is attractive commercially, however, because of its reactive unsaturated nature; it is used in preference to ethane for the manufacture of ethyl alcohol and ethylene dichloride. Ethylene is obtained by cracking ethane and propane. It is present in gases from thermal cracking processes. On cracking propane, propylene is also produced.

Ethylene dichloride is the starting material in making certain types of synthetic rubber. In the presence of water and chlorine, ethylene forms chlorhydrin, which may be converted into ethylene glycol, the well known anti-freeze sold under the trade name of "Prestone." Chlorhydrin also may be converted into ethylene oxide which is mixed with carbon dioxide and sold as a fumigant under the trade name of "Carbonozide."

Ethylene glycol and other glycols react with ammonia, forming the industrially important ethanolamines. Dioxan and other chemicals are likewise produced from the ethylene glycol which is also employed in the manufacture of Dacron. Ethylene as such finds application with propylene in artificial ripening of citrus fruits, for inducing growth of vegetables, and as anesthetics.

Propane

Propane, on oxidation or chlorination, yields the corresponding oxygen and chlorine derivatives. Commercially, however, propylene is employed in preference to propane.

Isopropyl alcohol is formed by uniting propylene with water in the presence of sulfuric acid acting as a catalyst. Isopropyl alcohol can be converted by the same process into isopropyl ether, which has been proposed for improving antiknock properties of aviation fuels. Glycerine is obtained by treating propylene with chlorine and water. Acetone is manufactured from propylene by a recently developed process with isopropyl alcohol as an intermediate product. By adding oxygen to propylene, propylene oxide is formed. It is used in the manufacture of propylene glycol, a component of hydraulic fluids, a tobacco preservative and a substance which found a number of other commercial applications. Phenol is made from propylene and benzene. The two hydrocarbons unite forming cumene which is oxidized to phenol.

Propylene combines with carbon monoxide and hydrogen forming butyraldehyde and isobutyraldehyde. This reaction is known commercially as oxo-reaction. Butyraldehyde is used in the manufacturing of plastics and mosquito repellents. On sulfonation propylene produces important detergents, that is soap substitutes.

Butanes

Butanes and butenes found commercial applications in the chemical industry, besides their use in the manufacture of synthetic fuels. Methyl ethyl ketone, an important solvent employed in dewaxing petroleum oils and for other purposes, is prepared from one of the butenes. Butanolamines are an example of other commercial products made from butenes.

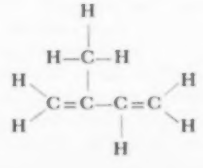
The present outstanding interest in these hydrocarbons is related to their use as raw materials in the manufacture of synthetic rubber. This development made the United States virtually independent from natural rubber supply in case of war and produced materials, which are superior in quality and of wider application than the natural rubber.

After World War I, the natural rubber market was controlled by England. We were obliged to pay much higher prices for it than would have resulted from free competition. This abnormal situation intensified the search for synthetic materials. Due to the foresight of the Standard Oil Company (New Jersey) we were in possession of all the German developments in this field and were working on our own processes.

World War II contributed to the process of these investigations and their commercial realization when the supply of natural rubber was cut-off by the enemy. As a result the use of synthetic rubber jumped from one per cent in 1941 to 85 per cent in 1945.

Hundreds of types of synthetic rubber are now on the market. They have their specific uses, for which natural rubber is not always suitable. For instance, butyl synthetic tubes are more durable than natural rubber tubes and hold air 10 times better, because they are less porous.

The early attempts to manufacture synthetic rubber involved the use of isoprene as the starting raw material.



$= C_5H_8$

Isoprene

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The method of attack was chosen since isoprene is obtained on decomposing rubber at high temperatures, thus indicating that it is the basic constituent of rubber. Recent developments have led to the abandonment of the attempts to use isoprene, as it has never been possible to produce this substance commercially at a reasonable cost.

Synthetic rubbers of commercial importance are made from butadiene, which has one of its hydrogen atoms replaced by chlorine. The raw materials employed in their manufacture are coke, lime, and hydrochloric acid. Buna rubbers, which are in many respects the best substitutes for natural rubber, are prepared by uniting butadiene with other substances, such as styrene or acrylonitrile. They are known under a variety of names, for example, Ameripol, Buna S, Buna N or Perbunan, Chemigum, Hycar, etc. The butadiene used in these processes may be obtained from petroleum or other sources. Various classes of synthetic rubbers include Thiokol, made from ethylene, chlorine and sodium sulfide; Vistanex made from isobutene; vinyl rubbers, like Keroseal, made by polymerizing vinyl chloride; and Butyl rubber, a reaction product of butadiene and isobutene. It is of interest that the synthesis of new substances in the petroleum industry start at high temperatures, while that of rubber is conducted at room temperatures or below. None of these synthetic rubbers is an exact overall substitute for natural rubber, although in some of their properties they may be superior to the natural product. For example, the abrasive resistance of the Buna rubbers is better than that of natural rubber. However, its adhesion to fabric is less satisfactory.

It is worth noting at this point the effect of speed on the wearing qualities of tires, both natural and synthetic. This is shown by the approximate figures presented in Table 1.

TABLE 1.—Effects of Car Speed on Wear of Tires.

Car Speed Mph	Relative Loss of Rubber for Equal Distance of Travel
25	100
30	106
35	120
40	136
50	200
60	430

In the summer the rate of wear is twice that in the winter. The above figures show that at 60 mph in the summer time 8.6 tires would be needed to cover the same distance which would wear out one tire in the winter time at a car speed of 25 mph.

Other Petroleum Hydrocarbons

Pentanes obtained by fractionating natural gasoline are chlorinated and converted into alcohols by hydrolysis, that is by reacting with water, which results in the exchange of the chlorine atom for the —OH group typical of alcohols. Hydrogen chloride is another product of the reaction.

$C_5H_{11}Cl$	+	H_2O	=	$C_5H_{11}OH$	+	HCl
Chlorinated pentane		Water		Amyl alcohol		Hydrogen chloride

Narrow petroleum fractions rather than pure hydrocarbons are used in these reactions. Mixtures of amyl alcohols and similar mixtures of butyl alcohols and their derivatives of the ether and ester types are used as solvents and are sold under the trade names of "Pentasol," "Pentacetate," "Cellosolve," "Cellosolve Acetate," "Butyl Cellosolve," "Carbitol," and others. These and other reactions leading to the production of various chemicals from pentanes were already described.

Processes used for manufacturing chemicals from benzene, which might be considered a petroleum product because it is obtained from petroleum commercially, are of many varieties and cover the field of industrial organic chemistry. They are well beyond the scope of the present chapter.

Petroleum fractions containing hydrocarbons boiling above pentane are at the present time not suited for manufacturing pure chemicals because of the difficulties encountered in isolating the individual components. However, processes have been devised for converting such fractions by various chemical reactions into mixtures of unknown composition which find industrial applications. Polymerization of highly cracked petroleum distillates in the presence of aluminum, iron or zinc chlorides yields resinous substances of the quick-drying type suitable for the manufacture of paints and varnishes. Drying oils that can be used as substitutes for linseed oil are obtained by treating with clay the highly cracked distillates containing diolefins. Synthetic lubricating oils are prepared by polymerizing unsaturated gaseous hydrocarbons in the presence of aluminum chloride. Paratone, employed for improving the viscosity index of lubricating oils, is prepared for similar raw materials. Oxidation of kerosene yields satisfactory solvents for lacquers. "Aldehol" used for denaturing alcohol is obtained by a similar process. Oxidation of paraffin wax produces acids suitable for manufacturing soaps, while chlorination of wax yields oiliness agents and additives employed as high-pressure lubricants. Plastics made from petroleum can be used in the manufacture of filter cloth, bathing suits, cloth, automobile parts, construction materials and an unbreakable glass. This glass is known under the trade names of "Plexiglass" and "Lucite" which have found a wide application in the manufacture of airplanes, because of their excellent visibility.

Besides hydrocarbons, other valuable compounds are found in crude oils, or may be obtained in the course of refining. Naphthenic acids are present in considerable quantities in certain crude oils, particularly those of the Coastal type. They introduce certain complications in the refining operations due to corrosion of distillation equipment. Naphthenic acids are separated from the oil by washing with caustic solutions. They are used in the form of soaps of various metals as dryers for paints and lacquers, as emulsifying or demulsifying agents, in the manufacture of soaps, and for other purposes. Recovery of naphthenic acids and phenols has been described.

Sulfonic acids are obtained as by-products from refining oils with sulfuric acid. Sulfonic acids soluble in the oil are known as "mahogany acids" and those soluble in water as "green acids." Mahogany acids are extracted from the oil with alcohol, which is then removed by distillation. Sulfonic acids are used as emulsifying agents, detergents, or as important constituents of certain lubricants; they may be obtained by interaction of solvent extracts with sulfuric acid. Chemical companies manufacture them using pure hydrocarbons.

Mercaptans, the worst smelling constituents of crude oil, also find a ready market. "Alcotate" and "Calodorant" used for odorizing natural gas as well as for denaturing alcohol, represent mercaptan-rich oils obtained from petroleum distillates. Amyl mercaptan, a vile-smelling substance, is specially prepared for this purpose from pentanes.

Practically every large petroleum company and many smaller ones are engaged in the manufacture of specialties. These specialties are sold partly for profit and partly to accommodate customers for other petroleum products. These specialties include polishes, insecticides and a host of other products which contain materials of petroleum origin as a base. For instance, the well known "Flit," "Bug-a-Boo" and similar fly sprays consist of a well refined kerosene fraction mixed with flower extracts, particularly those obtained from special varieties of pyrethrum, and which are poisonous to insects but not to human beings.

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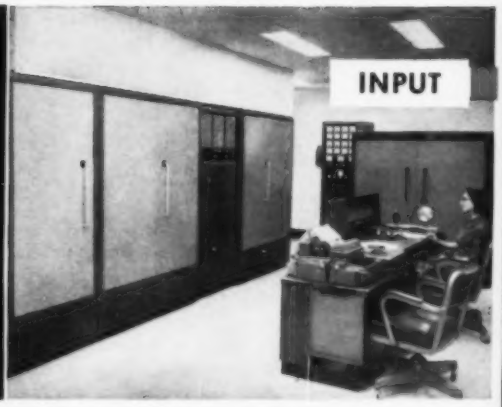
Electronic Route to

Super-Speed Computer Minimizes Heat Transfer Surface Requirements of Heat Exchangers . . .



Control section of Kellogg's computer

IN DESIGNING heat-pressure process equipment, the addition of a large magnetic drum digital computer to M. W. Kellogg's facilities enables the company's engineers to study variables and produce results with unprecedented thoroughness, accuracy, and speed. Human error is practically eliminated.

To Kellogg's customers in the petroleum and chemical industries, this new electronic aid means that Kellogg engineers can devote more time to basic design problems, and provide equipment with maximum operating efficiency, minimum maintenance costs, and the lowest possible initial investment.

In the case of heat exchangers, for example, design calculations require a trial and error solution. The time required to do this with hand calculations seldom permitted several design alternates. Thus the engineer never could be sure that the design selected was the true optimum. With high speed electronic computation, however, the greater number of alternates economically possible now brings the ultimate or near ultimate design to every Kellogg customer.

In one instance recently, involving 37 heat exchanger shells, the greater number of calculations achieved with the electronic computer resulted in reducing total heat transfer surface requirements by more than 15% from estimated values. Without the computer, the time required to obtain this value would have outweighed the saving many times, and would have been prohibitive.

Kellogg welcomes the opportunity to put its electronic computer and other engineering facilities to work for you. Arrangements to see the computer in operation in Kellogg's New York office can be made by contacting the company's Fabricated Products Division.

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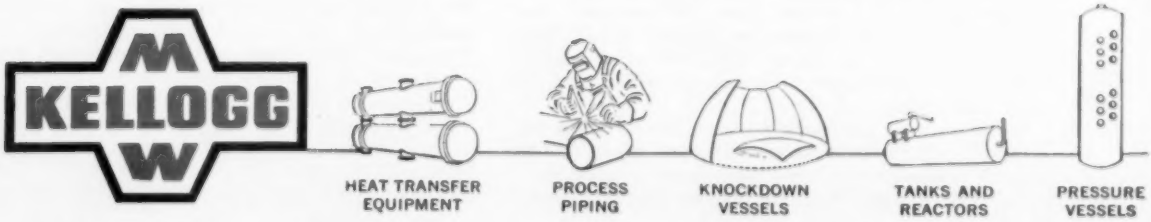

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Examine Performance and Design — **Reject** / **Accept**

Modify Design
Parallel series arrangement
Tube Passes
Shell Passes
Shell Size

Final Performance Evaluation
MTD, Resistances of Each Zone and Shell

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HEAT EXCHANGER

ITEM NO & TYPE	75634 0	
ARRANGEMENT SERIES PARA	2 F	
SURFACE TOTAL PER SHELL	6179 55160	1089 67630
TOTAL FLUID 100 LBS HR	140 00000	371 00000
DP GRAVITY LIQUID	87620	87620
TEMP VISCOSITY F CS A	53130 01306	53130 01706
TEMP VISCOSITY F CS B	53100 01100	53300 01805
TEMPERATURE HOT	300 00000	350 00000
TEMPERATURE COLD	130 00000	256 00000
TUBE PASSES PER SHELL	00000	2 00000
PRESS DROP ALLOW PSI	10 00000	15 00000
PRESS DROP CALCD PSI	9 96988	11 25021
FOUL RESIST & TUBE DIAMTR	00004	1 00000
DUTY MM BTU HR & MTD XTD	13 50000	MT 64713
TOTAL RESIST SERVICE CALCD	01436	01167
DESIGN PRESSURE PSI	150 00000	300 00000
TUBE NUMBER AND LENGTH FT	212 42078	20 00000
SHELL INS DIAM BAFF PITCH	100	0 31250

This liquid-liquid heat exchanger design flow sheet shows the route taken by Kellogg's electronic computer to obtain optimum design results. The boxes shown at right indicate the paths taken by the machine in arriving at the solution. Photograph at right is of a partial tabulation, showing how the computer presents results.

CATFORMING

For High Octane Numbers in Canada

H. R. Grane and J. A. Nevison
Atlantic Refining Company

THE long term predictions for motor gasoline octanes that were made several years ago have fallen far short of the actual octane levels available in today's gasoline stations. The rapid increase in octane level and the planned further increases in Canada are even more surprising than in the U. S. Early in 1955, the national average premium gasoline in Canada was less than 92 Research octane as compared to 95 in the U. S. During the past year the Canadian average premium gasoline has climbed rapidly and it is now only two octanes below the average for the U. S. premium. From the rapid increase in catalytic reforming capacity in Canada, we predict that Canadian octanes will soon equal the U. S. levels.

At the start of 1955 the catalytic reforming capacity in Canada was only two per cent of crude running or about one-fifth of that available in the U. S. However, by the end of this year, Canada will have 14 per cent reforming capacity which is as high as any country can boast. It is anybody's guess how extensive catalytic reforming capacity might be by 1960 when more cracked stocks, wider boiling-range feeds, and poorer quality stocks will be included in the reformer charge.

Over one-third of all cataytic reformers operating or under construction in Canada are Catformers. Five Catformers are now on stream, the first of which is located at the Calgary Refinery of the British American Oil Company Ltd. It started on stream in February, 1955, and is still operating on the initial charge of catalyst. The charge stock is made up of naphtha from several different crude sources in Canada and usually consists of the full boiling range naphtha. The Catformate has been maintained at 94 octane with 3.6 cc TEL per Imperial gallon during most of the run and up to 90 clear Research octanes for testing periods. The present catalyst life is about 135 bbl of feed per pound of catalyst.

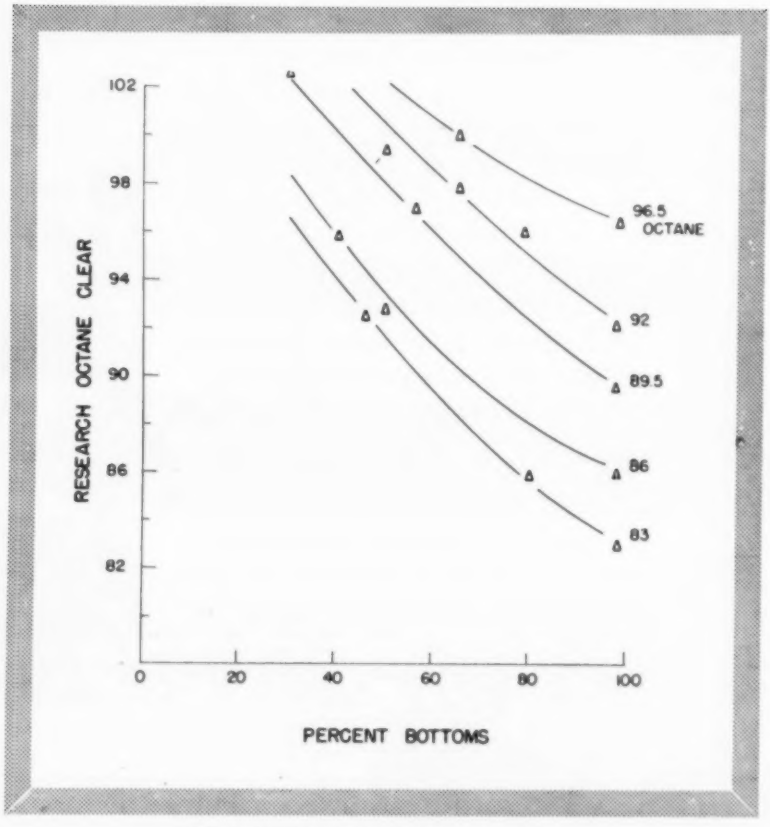

FIG. 1. **Octane ratings** of Catformate products.

Methods for High Octane Production

In the near future, the Canadian refiners will be facing the problem of marketing near 100 octane motor fuels. Catalytic reforming supplemented with other refining techniques must provide a solution to this problem. We have examined several techniques for producing super octanes such as splitting a Catformate into high and low octane fractions by simple distillation and using the selected stream as a means of meeting premium and regular requirements. Another method is thermally reforming a Catformate to crack out the low octane components. After polymerization of the C_3 and C_4 olefins

Condensed from the paper, "Catforming For High Octanes in Canada," by the authors who presented it at the 1956 Mid-Year Refining Division Meeting, API, in Montreal, Canada, May 15, 1956.

that are produced and blending of the polymer with the upgraded gasoline, a favorable yield-octane balance results. Another technique is to separate the high-octane material from Catformate and recycle the low-octane portion back to the reformer.

The first method of simple splitting does not increase the total pool octane of the refinery, but it *does* offer a simple, relatively inexpensive means of producing high-octane-blend components to satisfy requirements at premium octane levels. Our studies show that it is impossible at this time to justify combined thermal and catalytic reforming or recycle reforming if the required total octane pool can be achieved without it. The incremental investments for recycle reforming or two-stage reforming are two to six times as high as the additional investment for fractionating facilities. The operating costs, excluding amortization are also two to six times as high even after the proper charges are made for TEL, catalyst-life, and yield differences.

Fractionation and Reblending

Some typical Catformates have been fractionated to remove the front end in varying quantities and octane ratings were obtained on all of the bottoms fractions. A family of curves was obtained as show in Fig. 1. As the lower octane components in the front end are removed, the octane of the remaining heavy portion increases. For example, fractionation of a Catformate of 83 Research octane number, clear, into two 50 per cent cuts would give a bottoms stream of 91 octane, clear, and an overhead naphtha of about 75 octane. If desired, a heavy aromatic concentrate of 100 octane, clear, could be made by cutting a 20 per cent bottoms fraction.

Table 1.

	Total Catformate From LeDuc	Catformate 50% Bottoms	Catformate 50% Overhead
ASTM Octane (Research Method)			
Clear	88.0	97.3	78.7
With 3.6 ml TEL/I.G.	97.2	101.1	93.3
Reid Vapor Pressure	3.5	0	6.8
ASTM Distillation			
Initial	125	236	123
10%	190	252	165
50%	248	296	213
90%	330	351	234
End Point	409	413	252

One refiner in eastern Canada plans to meet their immediate octane problem by fractionation of its Catformate and cat-cracked naphtha, and reblending to meet both octane and volatility requirements for regular and premium gasolines. At a moderate Catformer severity of 86 per cent debutanized yield, product octanes would be 88 clear and 97.2 after the addition of 3.6 ml TEL per Imperial gallon. By separation of this Catformate into two 50 per cent pieces, cuts with the properties shown in Table 1 are obtained. The leaded octanes are 93.3 and 101.1 on the light and heavy cuts, respectively.

Table 2.

	Premium Catformate 50% Bottoms Plus Cat Naphtha 50% Overhead Plus Butane To 10 lb RVP	Regular Catformate 50% Overhead Plus Cat Naphtha 50% Bottoms Plus Butane To 10 lb RVP
ASTM Octane (Research Method)		
Clear	95.7	86.1
With 3.6 ml TEL/I.G.	100.1	95.6
Reid Vapor Pressure	10.0	10.0
ASTM Distillation		
Initial	80	80
10%	116	118
50%	290	244
90%	329	358
End Point	409	401
Per cent at 212F.	41	38

The properties of the debutanized cat-cracked naphtha are 4.1 lb RVP, 92.3, clear, and 97.7 leaded octanes. Splitting this naphtha into 50 per cent overhead and bottoms gives fractions with 98.9 and 96.5 leaded octanes. Blending equal quantities of the Catformer bottoms with the light cat-cracked naphtha and adding mixed butanes to bring the RVP to 10 lb, we get a premium octane of 100.1 with 3.6 ml TEL per Imperial gallon. The blend has 41 per cent evaporated at 212F. and is an excellent premium fuel. The properties of this premium blend and the properties of a similar blend made from the remaining low octane components which are suitable for regular gasoline are shown in Table 2.

Table 3. Catforming Kuwait Naphtha at High Severity

	Feed	Catformates		
ASTM Octane (Research Method)				
Clear	31.9	95.0	95.0	99.0
With 3.6 ml TEL/I.G.	61.0	102.0	102.0	104.1
C_5 Plus Vol Per cent Yield		69.0	77.8	71.1
ASTM Distillation				
Initial	276	100		100
10	288	125		150
30	294	166		221
50	300	239		290
90	320	315		339
End Point	364	370		406
Pressure		High	Moderate	Moderate

The foregoing example was based on a Catformate from LeDuc type naphtha, but the same approach can be applied to any naphtha stream. Reasonable fractions can be produced from Kuwait naphthas with octanes above the 100 Research level.

An ideal stock for blending with heavy Catformate is isopentane. Refiners located near gas wells or distillate fields and who process stocks containing a high percentage of pentanes will be interested in the Pentafining process.

Catalyst Development

As the octane requirement increases for our industry, improved catalysts are being developed that are durable enough to permit production of super octanes in conventional three-reactor Catformer units. This is demonstrated by the results shown in Table 3. Clear Research octanes of 95 to 99 were produced with excellent catalyst life from a heavy Kuwait reformer stock.

★ ★ ★

Construction Progress in Canada . . .

A steel helmeted worker directs the lifting of a 55,000-pound prefractionator tower at British-American Oil Company's Clarkson, Ontario refinery where a new 10,000 bbl per day catalytic reformer is being built. The unit is part of B-A's $14-million plus project that will triple Clarkson's capacity, bringing it up to 40,000 bbl per day rated capacity. Other projects include a 40,000 bbl per day crude topping and vacuum unit, a 12,500 bbl per day catalytic desulfurization unit, and extensive offsites facilities.

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U. S. Nuclear Submarine photo courtesy of Electric Boat Div., General Dynamics Corp. Groton, Conn.

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II. SELECTING EQUIPMENT

K. Methods for Fabrication and Inspection of Alloy Steel Piping

Walter W. Offner
Consulting Engineer

THE world's expanding industries require ever more and better equipment in order to fill the demands of the people. There is hardly any modern industrial plant which does not use some welded alloy piping, may it be for corrosive chemicals, high-pressure steam, radioactive waste materials, etc.

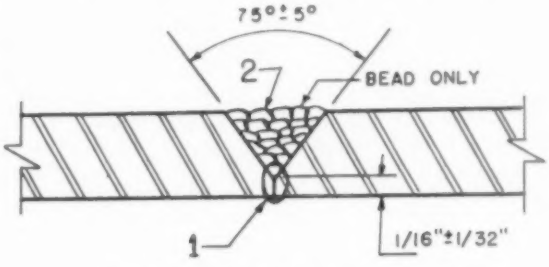
The industrial demand for higher pressures, higher temperatures, and higher corrosion resistance in process equipment could only be met by newer and better steels. The metallurgist was placed in the position of having to produce tailor-made steels and that is exactly what the steel manufacturer did.

Nowadays a designer can get the steel which exactly fits his requirements as to physical properties. The American Society for Testing Materials has tabulated and standardized these new steels, their qualities and possible uses and, in the case of welding, the welding electrodes to be used with these steels. Probably the largest consumers of these special steels for piping are the petroleum industry and the Government, both of which have their own specifications for their own special applications. Alloy piping for critical installations such as steam plants and oil refineries is usually designed to the American Standard Code for Pressure Piping.

Almost all welding of these special steels is done by the metallic arc process. In the last ten years great strides have been made in the development of inert-gas shielded arc welding for the fabrication of steel alloy piping as used in steam power plants, refineries, the chemical industry, and military and atomic energy installations. The inert-gas shielded arc welding process permits the production of high quality full penetration butt welds without the use of a backing ring. For critical piping, this process has been widely used, and some fabricators now find it economical to employ it for all alloy steel welding. Most of the tonnage in the United States is still fabricated using manual electric welding throughout, with or without backing ring, depending upon the judgment and preference of the owner.

The following procedure for tungsten arc-metallic arc welding of stainless steel pipe, conforming to the ASME and ASA Codes is in common industrial use:

The welding shall be done by depositing the first pass (root) by the Tungsten Arc method shielded by inert-gas and using an inert-gas back-up for prevention of oxidation and control of contour of the inside (root) bead. (Fig. 1). The balance of the weld shall be made by the Metal Arc Process. Filler metal shall deposit an alloy of the same composition as the base material. Bare wire is used for the passes installed by tungsten arc welding. Coated electrodes usually have coatings of the low hydrogen type. The edges of parts to be welded should be cut cleanly and accurately — preferably by saw or machine — and must be free of oil, grease, or scale. For tungsten arc work the current is usually d-c straight polarity; for the metal arc cover passes (Fig. 2) reverse polarity is common. Beads are carefully cleaned—usually with stainless steel tools—before the next pass is installed. Each pass should be carefully inspected for cracks or blow holes before proceeding to the next bead. Peening is not recommended. No preheating is used with these alloys and heat treatment after welding is a function of the size and design of the structure, the alloy, and the intended service. For services which have no record of causing intergranular corrosion or stress corrosion cracking, no heat treatment is required. For large, complicated structures which cannot be readily heat treated and which will be placed in service where intergranular corrosion is a possibility, the columbium or titanium stabilized or extra low carbon grades are used. In services where stress



1 — TUNGSTEN ARC INERT GAS SHIELDED

Electrode:	1/2" Diameter
Filler Rod:	None for flush—3/32" for inside reinforcement
Filler Rod: Material:	The filler material shall conform to the mechanical and chemical properties of the base material.
Gas Flow:	10 LIT/MIN—Pure Argon
Cup Size:	Number 6 Ceramic
Current:	80-100 Amps. D.C.
Voltage:	9-11 volts
Polarity:	Straight

FIG. 1. Procedure for tungsten arc inert-gas shielded weld.

FIG. 2. Shop welding of alloy pipe sections.

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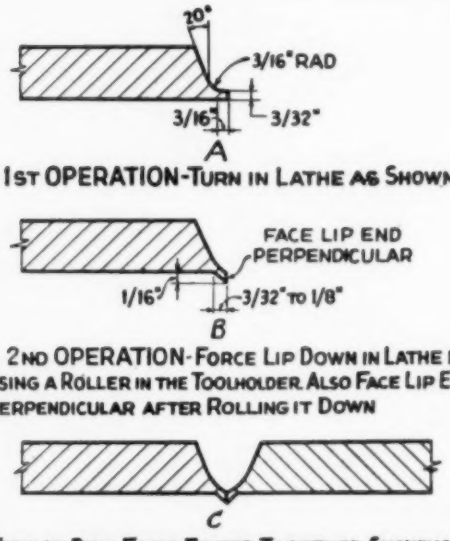

20°
3/16" RAD
3/16"
3/32"
A
1ST OPERATION-TURN IN LATHE AS SHOWN
FACE LIP END PERPENDICULAR
1/16"
3/32" TO 1/8"
B
2ND OPERATION-FORCE LIP DOWN IN LATHE BY USING A ROLLER IN THE TOOLHOLDER. ALSO FACE LIP END PERPENDICULAR AFTER ROLLING IT DOWN
C
VIEW OF PIPE ENDS FITTED TOGETHER SHOWING NEW TYPE BUTT JOINT DETAIL

FIG. 3. Novel preparation of root edges (Courtesy R. T. Purcell)

corrosion cracking is a factor, such as acid chlorides at elevated temperature, a stress relief heat treatment is desirable. The selection of temperature for the stress relief is a complex metallurgical problem, as the various alloys tend to embrittle at different temperatures in the stress relieving range. 1550 F to 1650 F is suitable for 18-8 grades, both ELC or stabilized, but may cause embrittlement of molybdenum bearing extra low carbon or stabilized grades. Cooling from stress relief should be reasonably slow — as in still air — so the stabilized or ELC grades are usually specified to prevent carbide precipitation when stress relief seems desirable.

Procedures used in fabrication of chrome-molybdenum alloy steel piping are much the same as outlined for stainless steel above, except that the filler metal must correspond to the parent metal in composition and properties, and preheat and stress relief heat treatment are essential to avoid cracking in fabrication or in service. The exact thermal treatment to be given these alloys varies somewhat from alloy to alloy, but for all chrome-molybdenum alloys having 2 to 9 per cent chromium it is considered sound practice to preheat from 400-600 F and stress relieve at 1300-1375 F. Most specifications provide that the hardness in the heat-affected zone of the weld shall not exceed 200 Brinell after heat treatment. For best results it is necessary to maintain the minimum preheat of 400 F throughout the welding sequence and until the piece is stress relieved. The most convenient method of doing this is with electric resistance or induction heaters which have come into wide use in the United States within the past ten years. In steam piping in particular but also in some refinery piping there is still some interest in procedures using austenitic weld metal for joining chrome-molybdenum alloy pipe and fittings. The alloy most commonly used is 25 Cr — 20 Ni although some nickel base alloys are used. This practice is decreasing in popularity as no effective heat treatment has been devised.

All piping elements to be welded into the line — flanges, fittings, and valves — should be of the same alloy as the pipe or at least compatible to the heat treatment necessary for the piping. Valve bodies, flanges, and fittings may be either forged or cast. Pipe in all standard sizes through 10-inch is readily available in seamless. Fusion-welded pipe is available in larger sizes and of excellent quality, although careful fabrication should be assured by good specifications and competent inspection.

R. T. Pursell of the Stone & Webster Engineering Corporation, in an article on welding of pressure piping, introduces a novel preparation of the root for welding stainless and Chrome-Moly pipe joints, as shown in Fig. 3. It is quite evident that with this procedure one has all the advantages of a back-up ring without any of the undesirable properties. Fig. 4 gives some details of this procedure for making single U-Butt joints on Chrome-Moly piping. The field erection of the shop fabricated sections is in most cases done by the same welding procedure. However, all welds are radiographically inspected after stress relieving.

The radiographic inspection of these field welds is rather difficult due, not only to the location of the welds, but also to the extra heavy wall thicknesses encountered, as shown in Fig. 5 and 6.

Some of the main steam piping for the electric energy plant in Joppa, Illinois, had wall thicknesses up to 4 in. Various radiographic procedures have been used for this type of work. It was evident that X-ray machines could not be employed; radioactive isotopes of large millicurie concentration were needed and the following procedures were used. (Fig. 7, 7A, 7B)

Method A placed the source in the center of the weld through a hole drilled through one pipe wall.

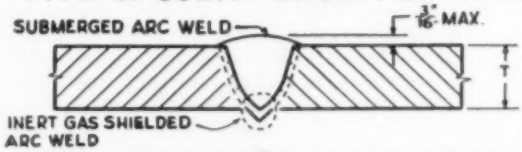
Method B had the source inserted into a sponge rubber ball which was then drawn through the pipe until it was in the center of the weld.

Method C placed the source right on the outside of the weld and took a radiograph of part of the opposite weld circumference.

Method D placed the source a distance of 7 times the pipe-diameter away from the weld and slightly off the plane of the weld to give an elliptical image of the weldment.

With methods A and B, one exposure radiographed the whole seam. With method C, a maximum of 55% of the weld could be radiographed with one exposure. The coverage with this procedure depends on the wall thickness and diameter of the pipe. With method D, an elliptical image

TYPE OF JOINT: SINGLE U-BUTT JOINT



INERT GAS SHIELDED ARC WELDING TECHNIQUE

BEADS	FILLER ROD	TUNGS'N ELECTRDE*	GAS CAP**	WELDG GAS ARGON CFH	PURGG GAS ARGON CFH	DC STR POL I	DC STR POL V
1	NONE	3/32	5L	15	5	120-140	10-14
2	1/8	3/32	5L	15	5	140-150	10-14

*THORIATED TUNGSTEN **METAL CUP, LONG NECK

SUBMERGED ARC WELDING TECHNIQUE

T	FILLER ROD	BEADS	DC — REV POL AMPS	VOLTS	WELDING SPEED IPM - AVERAGE
1/2	3/32	10	175 - 225	28-32	10 - 15
5/8	"	12	175 - 225	28-32	10 - 15
3/4	"	14	175 - 225	28-32	10 - 15
7/8	"	16	200 - 250	30-34	10 - 15
1	"	20	200 - 250	30-34	10 - 15
1 1/8	"	25	200 - 250	30-34	10 - 15
1 1/4	"	30	200 - 275	32-35	10 - 15
1 1/2	"	32	200 - 275	32-35	10 - 15
1 5/8	"	35	200 - 300	32-36	10 - 15
1 3/4	"	40	200 - 300	32-36	8 - 15
2	"	50	200 - 300	32-36	8 - 15

NOTES: The number of beads required may vary slightly, those given in the table represent an average.

The welding amperage, voltage and speed will vary between the first two or three beads and the reinforcement beads in order to obtain desirable results.

FIG. 4. Welding technique for Chrome-Moly Pipe (Courtesy R. T. Purcell).

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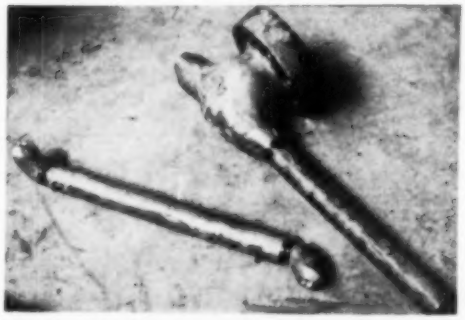


FIG. 5 and 6. Edge preparation of heavy walled pipe sections.

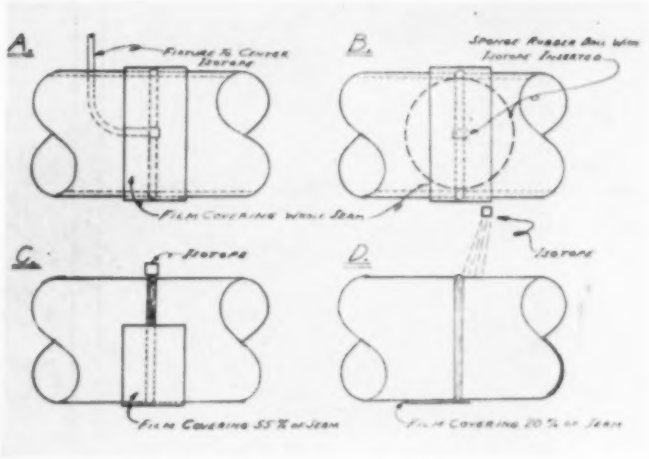
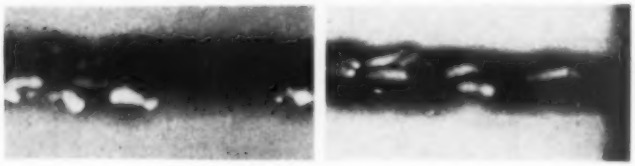


FIG. 7. Radiographic inspection procedures.

FIG. 7A and 7B. Typical welding defects as shown in radiographs.



of the weld was obtained giving about 20% of the upper half and 20% of the lower half in one exposure. However, the root defects were not detected by this method.

The prerequisite for good welding is proper laying out, cutting and fitting of the pipe sections.

Cutting shall be accurate and smooth, true to templates and beveled as specified in the Piping Detail Sheets. (Fig. 8) Cuts may be made by machine, by the Linde Powder Cutting process or the Arcos Oxyarc process. Bevels shall be machined or ground after flame or arc cutting, removing at least $\frac{1}{8}$" of metal.

Spacing of every joint shall be such as to obtain full penetration throughout.

Small tack welds, penetrating to the bottom of the groove, shall be used in fitting up. If free from cracks, they may become a part of the finished weld. Cracked tack welds or large tack welds are not acceptable and shall be chipped or ground out before laying of the first pass.

Welding Requirements

Qualifications: Before commencement of fabrication, the Supplier shall make available for review by the Purchaser's inspector, satisfactory evidence showing the Qualification of Welding Procedures and Welding Operators.

Miter Bends: Wrought welding fittings are preferred, but when miter bends must be used, welds on the inside radius shall be made with a uniform curvature. Welds with sharp corners or undercutting are not acceptable. Gusset plate reinforcements shall not be used unless specifically detailed in the Piping Detail Sheets.

Reinforcing: Reinforcing of branch connections, wyes, etc., shall be applied only as specified on the order or the Piping Detail Sheets. (Fig. 9.) All reinforcement pads shall be of same composition as the pipe and each shall be provided with a vent hole tapped for $\frac{1}{8}$" pipe. Welds to which reinforcement is to be applied shall be inspected by the Purchaser's inspector before application of the reinforcement. Welds with reinforcement pads shall be tested with air through the vent hole in the pads at a pressure and for a period specified by the Purchaser's inspector and the welds thoroughly painted with soap suds. Leak welds shall be repaired by the Supplier to the satisfaction of the Purchaser's inspector and retested. Upon completion of all fabrication and testing, the vent holes in all reinforcement pads shall be left *unplugged*.

Bending Requirements

All bends shall be smooth and free from flat spots, corrugations and indentations. Flattening of the cross-section of bends shall not be greater than 7½% of the nominal pipe diameter. When the requirements are such that the allowable flattening must be less than this, the order shall state the degree of flattening permitted. Bends may be made hot or cold. It is recommended that heating for hot bending be below 1000 F but not over 2000 F. (Fig. 10)

Hydrostatic Testing

When specified on the Piping Detail Sheets, fabricated piping shall be hydrostatically tested for a period specified by the Purchaser's inspector at the specified pressure in the presence of the Purchaser's inspector. All defects observed during the test shall be repaired by the Supplier at his

The Author

With the widest background in X-ray experience and training in many fields, Walter W. Offner, German-born engineer is president or vice president of five companies active in the X-ray inspection field, in Australia, India, Mexico, Hawaii and in continental United States. He is now head of X-ray Engineering International in California. He is well known internationally, having given a paper similar to the accompanying article in India recently. He is a member of the API, ASME, ASTM and several other important technical societies. He prepared the article on "Magnetic Inspection" in the Encyclopedia Brittanica and that on "Gamma-ray Inspection" for the Encyclopedia Americana, and has done considerable writing for publications. He was the subject of an article in Fortune Magazine, in 1953.

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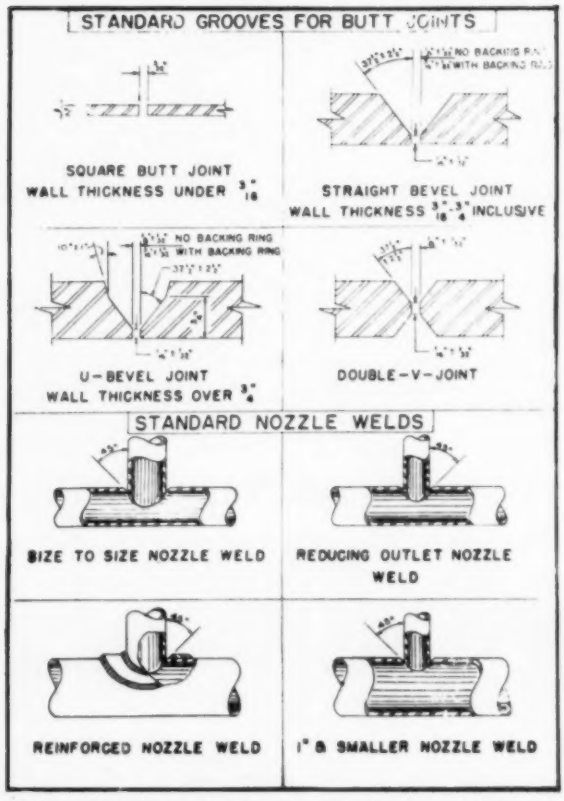

FIG. 8. Piping detail sheet (Courtesy Houston Pipe & Steel, Inc.).

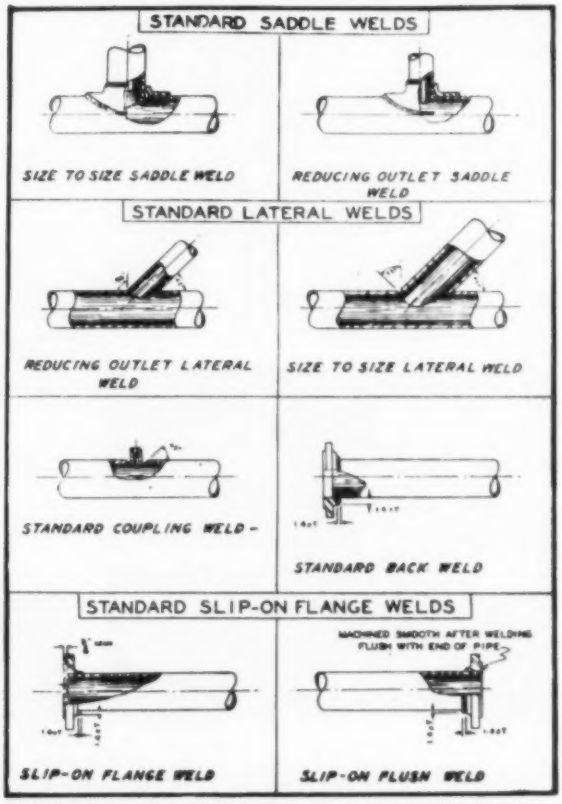
STANDARD SADDLE WELDS
SIZE TO SIZE SADDLE WELD
REDUCING OUTLET SADDLE WELD
STANDARD LATERAL WELDS
REDUCING OUTLET LATERAL WELD
SIZE TO SIZE LATERAL WELD
STANDARD COUPLING WELD
STANDARD BACK WELD
STANDARD SLIP-ON FLANGE WELDS
MACHINED SMOOTH AFTER WELDING FLUSH WITH END OF PIPE
SLIP-ON FLANGE WELD
SLIP-ON FLUSH WELD

FIG. 9. Standard saddle, lateral and fange welds (Courtesy Houston Pipe & Steel, Inc.).

FIG. 10. Pipe heat-treating furnace (Courtesy Associated Piping & Engineering Co., Inc.).

FIG. 11. Radiographic set-up using radioactive Cesium 137.

expense to the satisfaction of the Purchaser's inspector and retested.

Radiographing

Purchaser shall have the privilege of radiographing any weld at Purchaser's expense. However, when specified on the Piping Detail Sheets, welds made by the Supplier shall be radiographed at his expense. All defects, considered by the Purchaser's inspector to affect the strength and soundness of the weld, shall be repaired by the Supplier at his expense to the satisfaction of the Purchaser's inspector. All radiographic inspection shall conform to the requirements of paragraph UW-51 of the ASME Code for Unfired Pressure Vessels or paragraph P-102h of the ASME Code for Power Boilers.

Fig. 11 shows a standard radiographic set-up in a pipe fabrication shop using a radioactive isotope. It is recommended that all radiographic inspection is done by an independent third party inspection agency. The development of synthetic radioactive materials by the U. S. Atomic Energy Commission has been a major factor in the progress of the American welding industry. Not until recent years could small fabricators afford their own radiographic inspection facilities or outside inspection and weld control services. Radioactive materials are relatively inexpensive when compared to an X-ray machine installation, and these isotopes are also extremely portable. Wherever a weld can be made it can be inspected with isotopes. Until recently Cobalt 60 was the only isotope used for weld inspection. However, since late in 1954, Cesium 137 — which has a 33-year half life period — and renders improved radiographs, has been gradually replacing Cobalt 60 except for very heavy steel sections.

Without a doubt, more new isotopes will be developed in the future with even longer half-life periods, and the metallurgist will have available radioactive sources of suitable wave lengths for the non-destructive testing of almost all materials.

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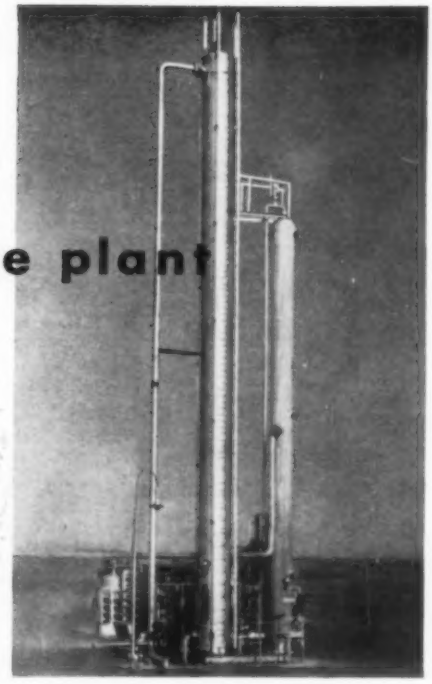
portable gasoline plant



The McNamar portable gasoline plant is designed to control the hydrocarbon content of sales gas and to economically recover natural gasoline and LPG.

The plants are also designed to fractionate the distillate, if desired. The ease of moving from one location to another, the simplicity in design, and the dependable operation of this unit are factors that greatly reduce operating and maintenance costs.

The usage of the McNamar portable gasoline plant is extremely flexible. The unit can be completely operated automatically, saving time and costs.

For dependable, economical gas plant operation, you can be assured of complete satisfaction when you purchase McNamar quality equipment.

Call, write or wire McNamar for further information.

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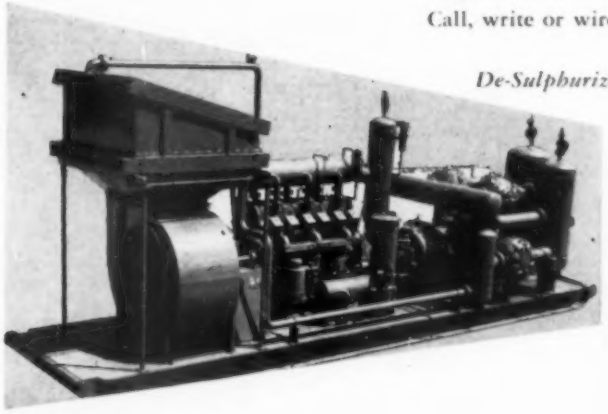

The McNamar Joy-Gas Compressor units are available in one, two or four cylinder models. Extremely portable, the unit can be moved on a tandem semi-trailer without disassembling.

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REFINING IN BRIEF

A New High Performance GREASE MIXER

O. L. Yarham
Archer-Daniels-Midland Company
Chicago, Illinois
and P. R. Sigler
Cities Service Research & Development Company, Cranbury, New Jersey

THE manufacture of lubricating greases, once considered an art, is rapidly becoming a science. Pilot plant work completed with a new versatile high performance grease mixer design indicates that an important step in the progression from art to science is being made.

Experience with the 30 gal pilot unit illustrated in Fig. 1 has proved that performance is satisfactory on all types of greases. The first large commercial unit, of 22,500 lb working capacity per batch, is being completed in the shops of the Struthers Wells Corporation for the Cities Oil Company grease plant, Cicero, Illinois. The second plant size unit is on order for the Arkansas Fuel Oil Corporation grease plant, Bossier City, Louisiana.

In developing this new grease mixer, the object was to combine in one vessel the benefits of high speed intensive mixing with that of the best time-proved design of the conventional counter-rotating wall-scraping type of agitator. The basic problem of grease manufacture is to provide maximum uniformity of mixing and temperature control through viscosities ranging from those of light liquids to those of extremely heavy pastes. The pilot tests indicate that this has been accomplished.

Condensed by the authors from the paper of the same title presented before the National Lubricating Grease Institute, and published in the NLGI Spokesman for November, 1956—Ed.

Experimental Pilot Unit

The pilot plant mixer is shown in Fig. 1 as it is installed in the East Chicago, Indiana, Laboratory of the Cities Service Research and Development Company.

The vessel is heated with saturated steam in the jacket up to 260 psig with alternate use of water for cooling. Heat transfer oil or other media could be used. The pilot kettle is equipped with a small Charlotte colloid mill and a variable speed gear pump which is used to recirculate the grease from the bottom outlet to the top of the kettle or to package through a small motor driven Cuno edge filter or through the colloid mill.

The kettle has a closed top with two sight glasses, one with a light. Internal working pressure is 150 psig maximum or full vacuum. As shown in Fig. 1, the vessel cover with motors, drive assembly and agitator may be opened or closed mechanically. Agitator blades on the center shaft are removable from the hubs and can be changed from high speed radial propeller to conventional in a few minutes. The counter-rotating wall-scraping agitator may be operated at conventional speeds from the horizontal gear motor. By the use of two free-wheeling clutches, the design permits the operation of the center shaft at high speed at any time by starting the vertically mounted overdrive motor. Because of the free-wheeling clutch features, no electrical interlocks are required.

The agitator selected for the high speed element of the new grease agitator combination is the Struthers Wells Radial Propeller Agitator. This selection was based on several years of

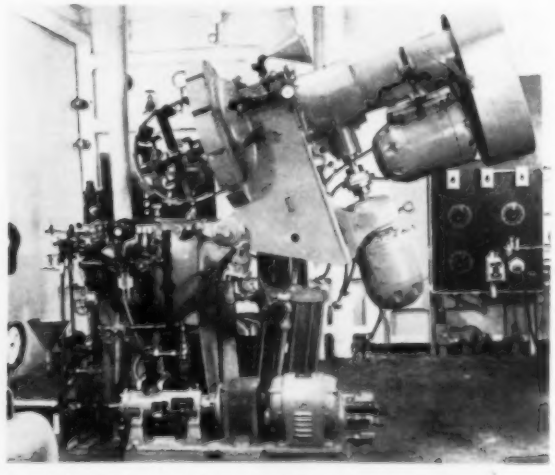


FIG. 1. **Pilot grease mixing unit** at Cities Service Laboratory, East Chicago.

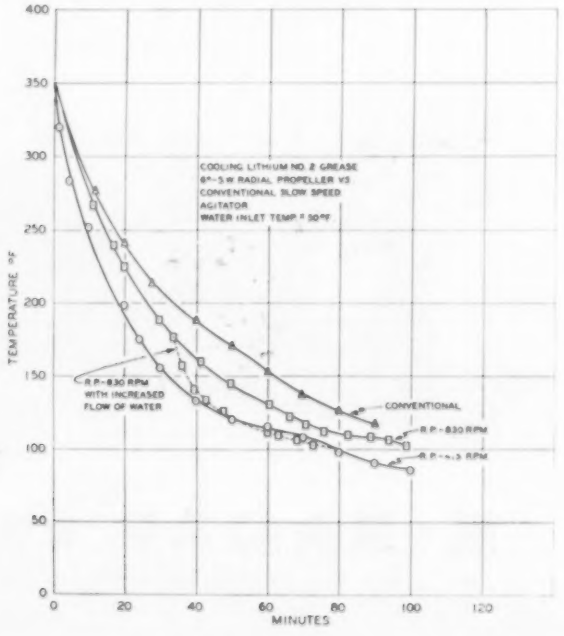
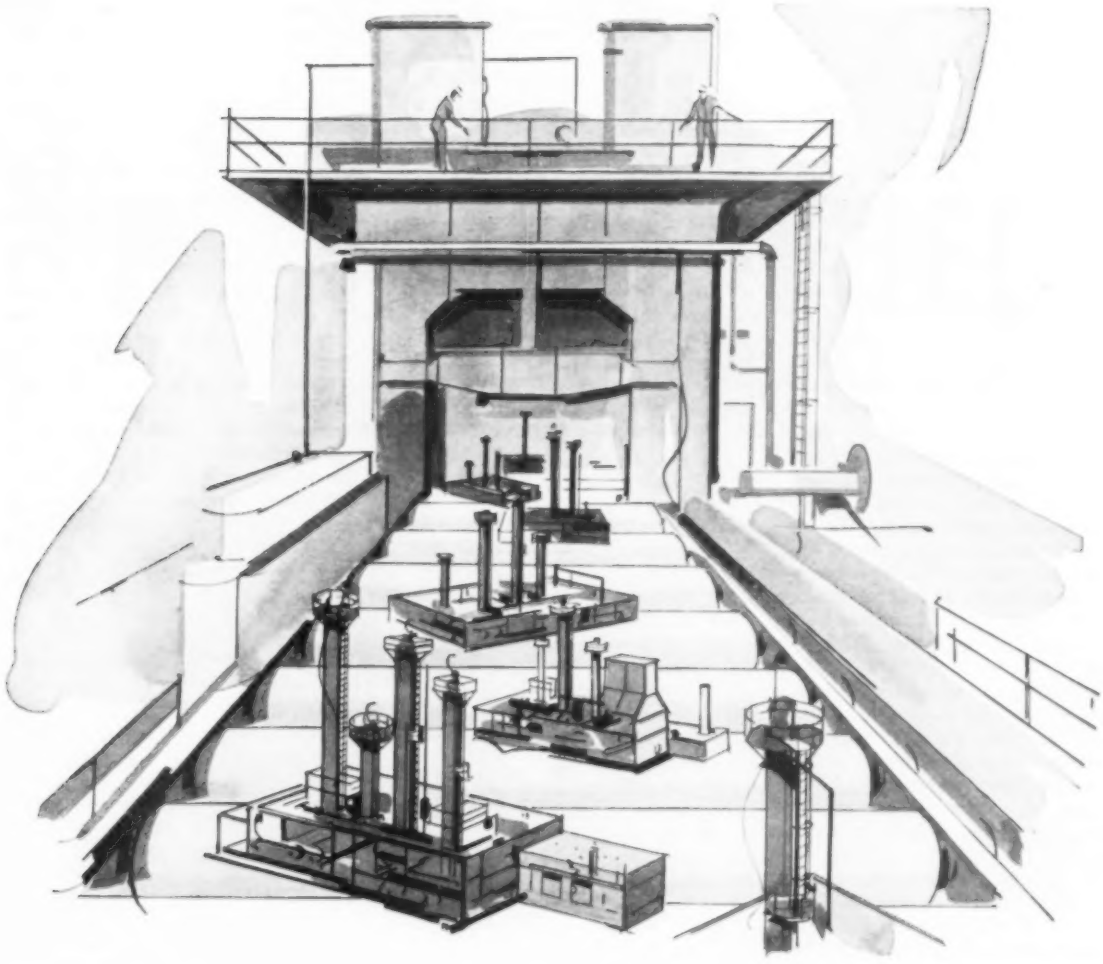
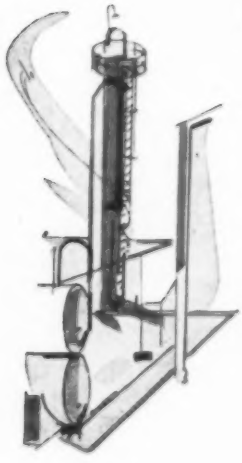


FIG. 2. **Comparative cooling time** for greases in different equipment at different stirring speeds.



There's no production line for plant construction



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WORLD-WIDE CONSTRUCTION FOR THE PETROLEUM, PETROCHEMICAL, AND CHEMICAL INDUSTRIES

study of various types of agitators with particular reference to the specific problems of present day grease manufacture. Articles of technical literature were reviewed. Manufacturers' technical bulletins agree that high speed impellers are not effective due to excessive channeling or cavitation in high viscosities such as exist during some stages of most grease processing. During operation in the viscous heavy soap stage, the result of the combination of the high speed radial propeller agitator and the conventional counter-rotating pitched paddle agitator is to utilize the folding action of the closely spaced pitched bars of the paddle kettle to move the viscous material into the intense mixing zone. This overcomes excessive channeling and thus obtains maximum benefits from the intensive high speed mixing element. During fluid conditions such as exist during the soap formation under pressure, the slow moving agitator bars and sweep frame act as baffles to prevent excessive swirl of the vessel contents.

Radial Propeller Agitator

The radial propeller agitator was developed by Struthers Wells in an attempt to combine the advantages of the marine type propeller and the turbine type agitator. The vertical blade faces are at an acute angle from the tangent and propel material radially outward. As these vertical blades operate at high peripheral speeds an excellent mixing and shearing action on the grease is obtained. This is useful during soap formation, during dehydration and during oil addition to the soap stock.

The pumping action of the turbine feature of the agitator combined with the paddle kettle action brings rapid equilibrium throughout the kettle contents and eliminates the extreme gradients of temperature, moisture and composition now found in existing plant equipment. As a high rate of new surface is exposed, dehydration and dearation (under vacuum) is rapid.

Pilot Plant Grease Processing

The work with the pilot equipment has demonstrated that better control of process variables can be obtained than is possible by the use of any equipment known to be installed at this time. Overall manufacturing time savings ranging from 30 to 80 percent of present time cycles are indicated.

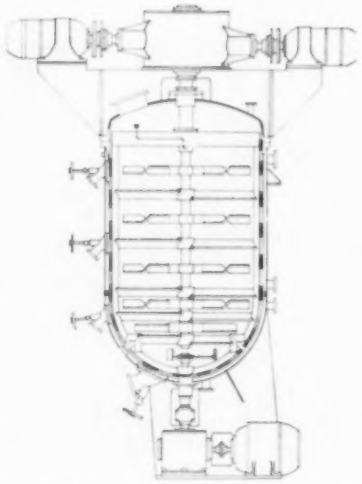

FIG. 4. **First commercial-scale mixer** design, for 22,500 lb-per-batch capacity.

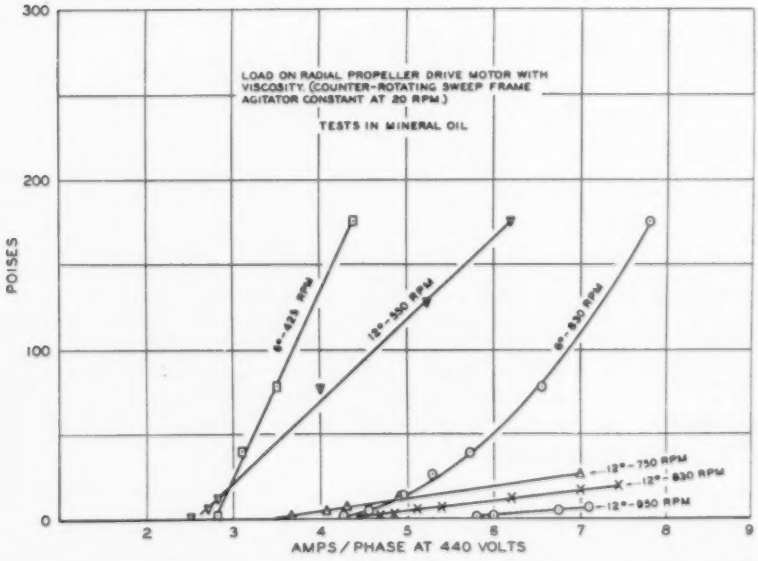

FIG. 3. **Test data showing power required** for the unit at different speeds and with 6° and 12° pitch agitators.

Overall heat transfer coefficients ranging from 1½ to 4 times those obtained in the same unit with the conventional agitator have been obtained with the new combination agitator.

The following data is illustrative of some of the test information obtained in the pilot kettles in evaluating the effect of the radial propeller-scraper type sweep frame agitator combination compared to the conventional agitator in heating a No. 2 NLGI grade of multipurpose lithium soap base grease. In all cases, the scraper sweep frame agitator was constant at 20 rpm and the only variable was the center agitator. For the conventional agitator test, the center shaft speed was 30 rpm. With steam in the jacket in each case condensing at 356 F, the following times were required to heat the grease from 125 F to 340 F:

Conventional agitator	120 min
6° Pitch radial propeller @ 830 rpm	31 min
6° Pitch radial propeller @ 415 rpm	57 min

The time necessary to cool grease to the desired packaging temperature or colloid mill feed temperature presents as much or often a greater problem than heating time in some plants. Fig. 2 shows results with the same agitator combinations when cooling the lithium No. 2 grease. For the three solid line curves, the jacket cooling water temperatures and flow rates were identical. The broken line shows the need for additional flow of cooling medium when the radial propeller is operating at the higher speed of 830 rpm. This is to compensate for the heat effect of the increased horsepower input to the agitator. Fig. 3 shows test data obtained on power requirements of the radial propeller agitators in the pilot equipment with the agitators operating in a viscous mineral oil. The pilot mixer was charged with 220 lb of the oil. For all the test data taken, the sweep frame agitator speed was constant at 20 rpm. It is worthy of note that for the 12° pitch agitator all the power curves are straight lines through all test speeds to and including 950 rpm. For the 6° pitch agitator, the power curve is a straight line at 425 rpm. At 830 rpm considerable curvature is developed. This indicates additional slippage and shear on the product near the blades with some loss of pumping action of the vertical pitched blades and less mass flow. The 6° pitch agitator may thus be described as less power sensitive to viscosity than is the 12° pitch agitator.

Agitator Combination

Observations and physical and chemical tests based on work with the 30

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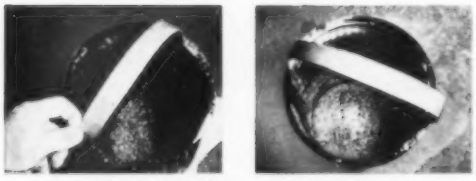

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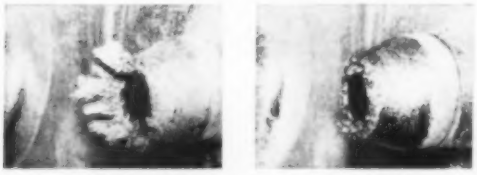
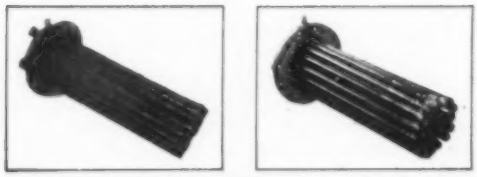
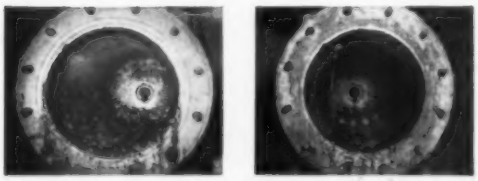


NOZZLE-FOULING . . . solved by FOA-2



PREHEATER TUBE-FOULING . . . solved by FOA-2



PREHEATER-SHELL-FOULING . . . solved by FOA-2

Du Pont Fuel Oil Additive No. 2 has been proved a highly efficient sludge dispersant for residual fuels. In every test, the additive has succeeded where other—and often much more costly—methods have failed. Our own experience, in Du Pont manufacturing plants, has repeatedly confirmed these findings.

FOA-2 has cleaned many tanks too sludge-laden for operation, and the dispersed sludge has been burned without furnace shutdown. After these cleanings, the continued use of FOA-2, in small concentrations, has *kept* nozzles, filters and strainers clean, practically eliminating fouling and reducing the need for expensive tank cleanings to an absolute minimum. Being nonmetallic, FOA-2 itself burns completely, leaving no ash.

Users get all this protection, all this insurance against operation failure, with only a minute quantity of FOA-2 per barrel of oil. Storage space is kept available for storage of residual fuel—*not sludge.*

The Du Pont Petroleum Laboratory recently issued a technical memorandum (No. 317, dated January 1957). It reports in detail ten typical case histories of residual fuel problems solved with FOA-2 . . . in a refinery, and in large industrial plants, an apartment house, a power station and a country club.

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gal pilot unit indicate important practical benefits may be obtained from the high speed agitator at all or nearly all stages of grease processing. During soap formation under pressure, the vessel contents range from very fluid to moderately fluid. At this stage, the radial propeller creates a rapid overturning of the vessel contents and as the processed material passes the agitator blades an intimate contact of reacting ingredients is obtained. Soap formation is apparently completed before the maximum temperature is reached. In a typical pilot run, this time to reach the maximum temperature was 12 minutes.

During the fluid soap formation stage, the slow moving sweep frame and pitched agitator bars act as moving baffles. The hemispherical shape of the bottom head of the vessel is quite useful in determining a desirable flow pattern and in providing a reasonable depth of contents. This is particularly useful in processing some of the newer low soap content greases.

As the high soap content material is allowed to dehydrate, the mass becomes more viscous and the load on the radial propeller drive motor is noted to increase on the load indicating ammeter. (A smaller typical load increase is also observed during the previous pressure cooking as the soap is first formed.) When the dehydrated high soap content material becomes more viscous, the folding and axial flow action of the slow moving pitched horizontal paddle blades serves to move the material into the intense high speed mixing zone.

After the desired degree of dehydration has been obtained, mineral oil is added to the vessel to reduce the product to the desired consistency. The load indicating ammeter on the radial propeller drive motor is very useful in determining the proper flow rate of oil addition in processing some greases.

Full Scale Equipment

The first commercial size grease mixer based on the pilot plant unit is illustrated by Fig. 4. This kettle will have a working capacity of 22,500 lb of grease per batch. The sweep frame agitator and the center paddles each are independently driven by one of the top two-speed constant torque drive motors. The bottom radial propeller drive motor is four-speed constant torque. In the design of this unit, none of the best useful features of the time-proved counter rotating wall-scraping type of grease mixers have been eliminated and an important new feature has been added. This first unit is now scheduled for installation about June, 1957.

Economics

A pre-construction study of the economics of the installation of the combination agitator versus a similar mixer without the high speed element resulted in a strong recommendation for the combined agitator. The estimated "pay-off" time to recover the increased cost of the addition of high speed radial propeller was less than two months. This estimate was based solely on process time saving. Additional benefits not figured in are improved product quality and uniformity.

Continuous Grease Manufacture

On grease products where sufficient volumes exist to merit the installations, the writers believe that multiple units properly matched for sizes could be arranged for continuous or semicontinuous operation in order to obtain any possible benefits from such operation. Intermittent return to batch processing could be made with a minimum of time and effort with little if any loss of the flexibility of operation inherent in batch equipment.

REFINING IN BRIEF

P 731.

Models Very Efficient as DESIGN TOOLS

Bruce L. Paton
Fluor Corporation, Ltd.

THE design and construction of refineries, power plants and petrochemical plants involve the solution of many and varied problems. Before a plant can go "on stream," these problems must be recognized, and then solved by a team of engineers, designers and constructors, each a specialist in his field. The means of communication between various members of this team is critical and at best, difficult. If each member spoke a different language, the job of integrating ideas would be tremendous. In a sense, this language differential does exist.

Practically every part of design is a three dimensional problem. In spite of this obvious fact, it has been the accepted practice to express the solutions with two dimensional drawings. Even very capable engineers and constructors lose time in the translating process. Reference to several drawings is usually required before the translation is complete. There is also the possibility that the thought will suffer and omissions will occur in the translation. It is not practical to include each and every detail in the several views or drawings required to convey an idea on paper. This is the reason why The Fluor Corporation, Ltd. has adopted the visual design language common to every team member — Scale Models.

It has been the universal comment of Fluor customers and their consultants that the designing of a job with the use of a model is a great time saver for them. On a model, they are able to review in hours what previously would have required days. They have a much better feel of the job than they would have with nothing but drawings to work from. There is less misinterpretation of what Fluor is planning and, therefore, there are fewer changes in the later stages of design and after the plant is built.

A model is the only practical tool we know of which enables a person to get all of the principals concerned together at one time and expedite decisions and action. We were never able to get a fair sized group of people to sit down together and go over a set of drawings. More can be accomplished in half a day over a model than can be done in weeks by the transmittal and return of drawings, around the country, or the plant. A model eliminates not only the calendar time that was in the past necessary to obtain these decisions, but also most, if not all, the uncertainty that often accompanies the attempted visualization of a plant from drawings alone.

Saving Drafting Expense

The only sure way of pinning down the value of a model is to use it in the design stage of a plant, and then compare costs against conventional drafting methods. We have done that and we know that we can justify the cost of models strictly on a design and draft-

*Condensation of ASME Paper presented at the annual Petroleum Meeting in Dallas November 23-26, 1956.

DUPONT *Petroleum Chemicals* NEWS

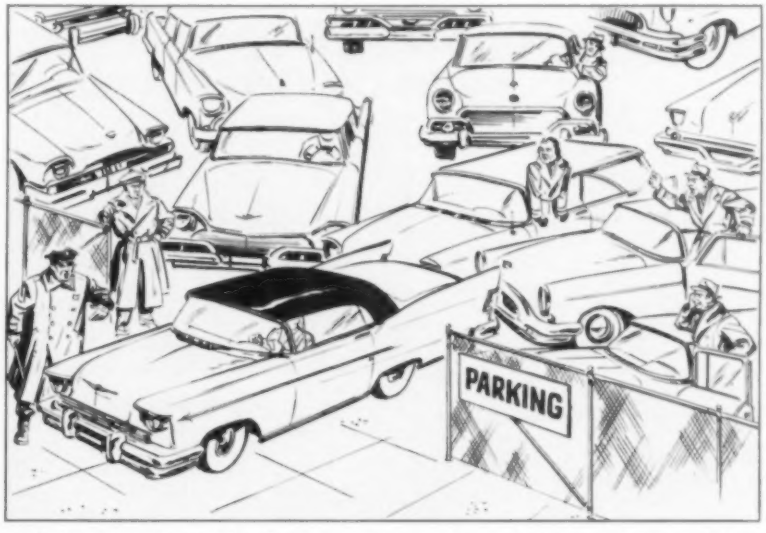
One of a Series of Bulletins for the Petroleum Industry

APRIL 1957

Experiments reveal facts about carburetor icing

Recent experiments indicate that stalling due to carburetor icing occurs even in 55-degree weather. Moreover, they prove that DuPont DMF (dimethyl formamide) provides the motorist with protection against this type of hazard and annoyance.

Stall-prevention is especially important in many cars having power brakes and power steering—both of which are less effective when the car-engine stops.



STALLS DUE TO carburetor icing often happen at the most inconvenient times, such as the rush-hour traffic jam in the parking lot above—caused by the stalled car at the exit gate. Our growing traffic congestion especially points up the need for eliminating situations like this. When DuPont DMF is added to gasoline, it effectively prevents carburetor icing stalls which occur under a wide range of temperature and humidity conditions.

Dimethyl formamide proved effective in low concentrations

Its practical use concentration turned out to be under 0.10 volume per cent—in other words, less than three milliliters per gallon!

Long stalling season

Conditions under which your customers' cars can stall also became clearer. The "refrigerant" action of gasoline can lower the temperature of carburetor parts to freezing even on comparatively warm days. Generally speaking, temperatures from 22 to 55 degrees Fahrenheit can lead to carburetor icing when humidity is 65 per cent or higher.

Expanding de-icer market

Motorists are showing an ever-increasing interest in gasoline performance. By anticipating a greater demand next fall for gasolines which contain anti-stalling agents, you can increase the

GENERAL MANAGER ORGANIC CHEMICALS DEPARTMENT

SAMUEL G. BAKER began his career in 1923 on a dynamite production line at the DuPont explosives plant in Washington. Six months later, he left the company to resume his university career.

After graduating in chemical engineering from the University of Washington, Mr. Baker returned to DuPont

in 1925 as a chemist at the Eastern Laboratory and the Repauno Works in Gibbstown, New Jersey. In 1939, he was named Director of Sales of High Explosives Manufacturing Division. Four years later, Mr. Baker joined the Electrochemicals Department, where he became General Manager in 1948.

He became General Manager of the Photo Products Department in 1950. The Organic Chemicals Department is the third department Mr. Baker has headed. He was appointed General Manager of that department late last year.

ADVERTISEMENT—Prepared for the Petroleum Chemicals Division of E. I. du Pont de Nemours & Company (Inc.)

OVER

DUPONT *Petroleum Chemicals* NEWS

New Du Pont engine assembly demonstrates carburetor icing

MARKETER:

So this is the apparatus you use to demonstrate carburetor-icing characteristics of gasolines?

DU PONT REPRESENTATIVE:

Yes, it consists of a 1.6-horsepower engine connected to a small ice tower by a glass tube manifold.

MARKETER:

I see there's a build-up of ice on the little metal throttle plate in the tube . . .

DU PONT REPRESENTATIVE:

That's right. The fuel being tested contains no anti-icing additive – see, the engine just stalled! Now watch it take hold again when the DMF is added.

MARKETER:

Say, this unit would come in handy at our next dealer meeting . . .

DU PONT REPRESENTATIVE:

We'll help you build one. You'll find it very convincing for selling dealers and customers on your new NO-STALL GASOLINE with DMF.

Increased use of additives leads to greater yields of stable products

When insoluble residues form in distillate fuels, it usually means trouble for the user – and often for the supplier. Maintaining fuel stability is the key to solving this problem. And, in most cases, the use of additives has been found to be the most economical solution.

The trouble and the cure

Residue formation is more of a problem today than ever before because of the increased use of catalytically cracked stocks. Although cat-cracked stocks are as good as straight-run stocks in heating value, they are generally less stable in storage. As a result, users experience troubles caused by sludge.

In the case of domestic heating oils, for example, unstable stocks can lead to plugging of filters, nozzles and other parts. Du Pont Fuel Oil Additive No. 2 (FOA-2), a stabilizer and dispersant, inhibits the formation of those sediments.

Diesel fuels improved with FOA-2

Users of diesel fuels also encounter stability problems. The formation of insoluble residues in cat-cracked stocks can lead to injector-sticking, build-up of undesirable deposits in combustion chambers and loss in engine performance. Diesel fuel refiners are discovering that these problems, too, can often be overcome by the addition of Du Pont FOA-2 to their cat-cracked stocks.

FOA-2 is ideally suited for stabilizing all types of fuel oils. A small amount will not only prevent formation of residues, but will disperse them as well. Thus it tends to rid oil-feed systems of any sludge that may have previously formed.

Technical paper available

As the need for greater fuel stability grows, you will be looking for the most economical way of obtaining it. In a technical paper entitled "Improving Fuel Oils through the Use of Additives," W. deB. Bertolette and J. D. Rogers describe additive treating as a relatively simple operating procedure and point out how economical it is compared to refining or other treating processes.

To get your free copy of this paper, just send your request to any of our sales offices listed on this page.

CONTINUED *Carburetor Icing*

number of your cold-weather customers. Now is the time to anticipate the day when temperatures begin dropping below 55 and carburetor icing begins.

Economy and reduced storage

DMF offers two important benefits – economy and minimum storage-space requirement. The low volume concentration that's needed represents a real saving in freight and blending costs. And, because of the high efficiency of Du Pont DMF, and the low concentration required, little storage space is necessary.

See the "demonstration" of DMF, top of page.

A Du Pont Petroleum Chemicals Division representative will be glad to give you more detailed information on DMF. You can contact him at any of our sales offices listed at right.

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Better Things for Better Living
. . . through Chemistry

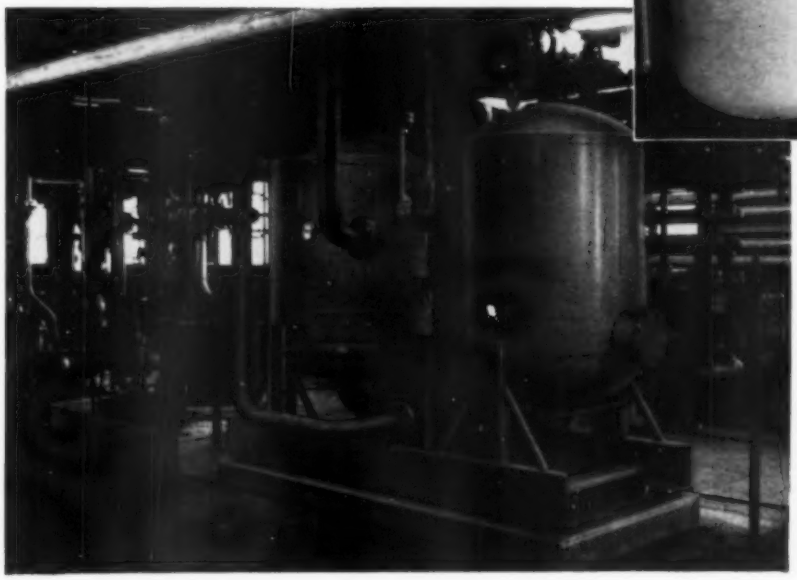
OVER

ADVERTISEMENT—Prepared for the Petroleum Chemicals Division of E. I. du Pont de Nemours & Company (Inc.)

A-4216

Printed in U. S. A.

If it's air-controlled, feed your instruments DRY air



This compressor, air tank and Type BAC Lectrodryer combination serves a comparatively few instruments and valves.

Hundreds of instruments, widely scattered throughout a giant plant, are fed DRY air by this centrally located BY-9 Lectrodryer.

TAKE NO CHANCES on failure of instruments and air motors caused by fouled air lines. Install a Lectrodryer* to remove the vaporous moisture from the air as it comes from the compressor. Then there will be no water to form ice, rust or mud.

Small operation or large, there's a Lectrodryer to meet every DRYing requirement; for low or high pressure work. It can be fully automatic or manual, requiring only the infrequent reversal of a valve to regenerate the dryer. Its DRYing is continuous, year after year.

Bulletin 223-B describes these instrument air dryers. For a copy, write Pittsburgh Lectrodryer Division, McGraw-Edison Company, 334 32nd Street, Pittsburgh 30, Pennsylvania.

Lectrodryer

*REGISTERED TRADEMARK U. S. PAT. OFF.

ing basis if they are used during the design stage of a job.

With the use of models we save both man-hours and calendar time in designing and constructing our plants. During the first full year that Fluor used design models on every major job undertaken, drafting costs were $100,000 *less* than the previous year, and gross business for that year was slightly more.

Design Training

Through the use of models, we make better use of our existing force of scarce, highly trained people to easily and quickly develop our plants in model form. We then can rely on lesser trained people to complete the detailing.

Better Plants

Piping layed out with the aid of a model is shorter and more direct. Less pipe elbows are used. Friction loss is reduced, sometimes allowing use of the next smaller size pipe or reduced pumping horsepower.

Access to manholes, hard to reach valves, instruments, and machinery can be much better visualized from a model than from drawings. As a result plants built using design models show considerably more planning for operators and maintenance.

Three types of models are used for design at Fluor.

1. Plant Layout Model
2. Piping Layout Model
3. Piping Arrangement Model (full scale)

Each of these types serves a specific and different purpose.

Plant Layout Model

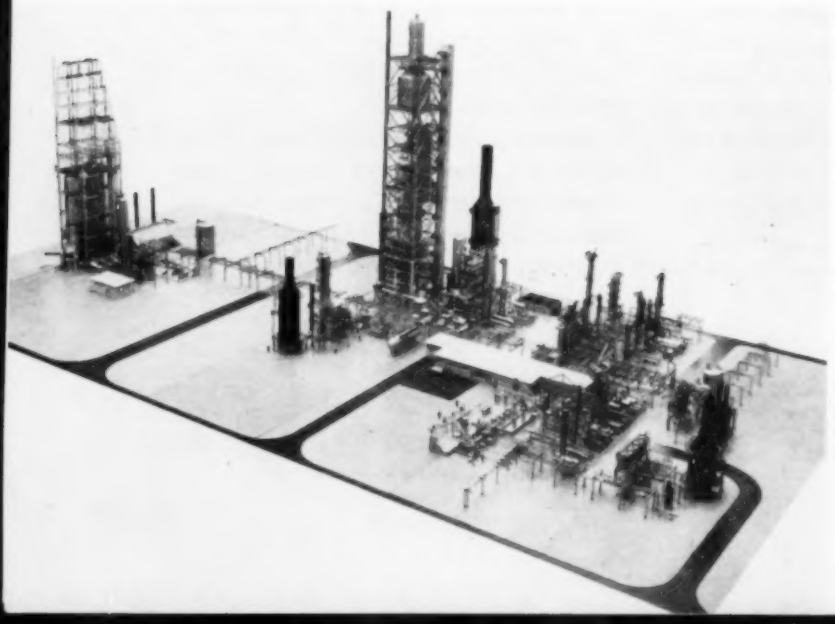
The Plant Layout Model was developed to serve as a focal point, a clearing house for plant design, coordinating the activities of all our various specialists. On tight schedules, coordinating their efforts for maximum efficiency becomes a big problem. Designing plants in model form first allows each of these groups to have a composite picture of the whole job sooner. They can, therefore, get an earlier start on their detailed construction drawings.

How then do we go about developing a plot plan through the use of a Plant Layout Model? First, the process engineers furnish process flow sheets and equipment specifications to all concerned. Mechanical flow sheets are drawn. A rough sketch of the plot plan is drawn. The process units are indicated by blocks only. Equipment for the Plant Layout Model is made using preliminary outlines. The piping layout designer then arranges the equipment to the best of his ability to suit the piping condition of the job.

Interferences may begin to show up at this point or it may be necessary to change the overall arrangement to secure a better plant. If this occurs, a fresh start is made. Here is where some of our measurable savings occur. It is *easier and quicker to rearrange equipment on the model than on paper*. Our plants have been cleaner and more orderly, from a design sense, since Plant Layout Models were initiated. It is considerably easier to build this orderliness into a model than it is on drawings. Possibly even more important is the fact that early approval of the layout on this model allows us to proceed to the next step in the design with less chance of change than we ever could with layout drawings.

Upon completion of this model a conference is held to approve the layout. A formal plot plan is then drawn of the approved arrangement shown on the model.

A piping design model employed in working out the meticulous details of such a design, lessening greatly the chances for error or misunderstanding.



Piping Layout Model

The Piping Layout Designer starts the layout of the piping in the plant by first transposing the mechanical and utility flow sheets to the Plot Plan drawing. This is to generally locate orifice runs, control valves, widths of pipeways and general space requirements. The paper work is kept to a minimum. Meanwhile, pieces of equipment are being made by model shop personnel for the model. All equipment operating together as a process unit is painted the same color to allow easy identification. Model equipment is given to layout designer who indicates location of manholes, nozzles, platforms, and ladders on vessels and returns them to model maker. Model maker drills the nozzles, mounts platforms, ladders, and manholes, etc.

The equipment is then mounted on plot boards. The piping layout designer directs, either verbally or with sketches, the model maker in routing the piping on model. This is done in a temporary manner using materials which have flexibility and allow changes to be made easily and quickly. All piping is shown with 1/16-in. diameter brass rod regardless of actual size. True OD of pipe is indicated with short lengths of rubber sleeving. Direction of flow, line number, specification and insulation is indicated with plastic snap-on arrow shaped line tags. These are placed on the lines as they are installed. Valves, orifice flanges, instrumentation, etc., are indicated by castings, slotted to fit on the brass rod.

While the model maker is installing pipe, the designer is working out close fits on sketches for future use in making spools, or arrangement drawings. He also is firming the location of working platforms, structures, etc., with the help and advice of the structural specialists.

During the period of installing pipe on the model, other design groups such as Electrical and Instruments are viewing the model and making sketches to locate their equipment. Racks for electric and instrumentation lines are installed on the model as the information is developed.

When the Piping Layout Model is complete, a formal job conference is held. Project, process, construction, customer's representatives, all principals and key men concerned are represented. Changes are agreed upon or approvals given.

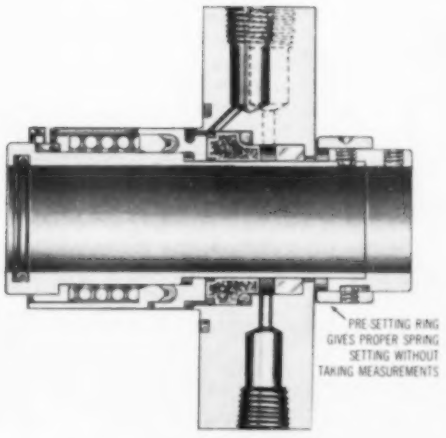
Normal procedure at Fluor after obtaining approval of the Piping Layout Model is to start a minimum number of piping arrangement drawings. These, together with spool drawings and the

BIG SAVINGS FOR PIPE LINES!

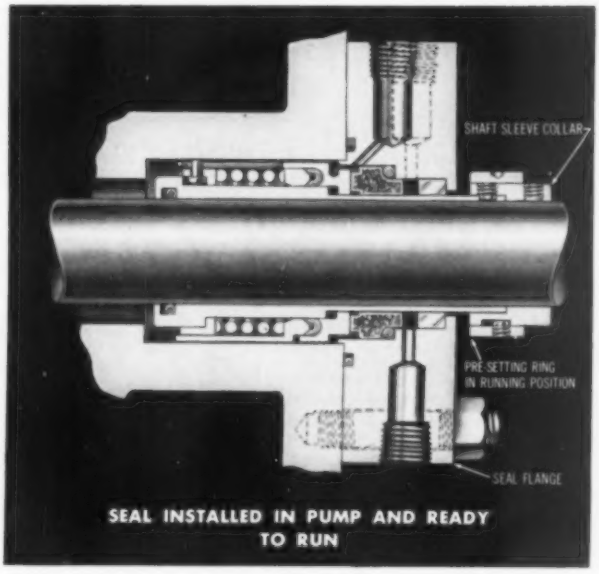
New

BJ Mechanical Seal

with automatic Pre-Setting Ring (Patent Pending) assures perfect installation ...without measurement



SEAL ASSEMBLED FOR INSTALLATION AS A CARTRIDGE UNIT



SEAL INSTALLED IN PUMP AND READY TO RUN

Perfect installation of BJ Mechanical Seals is now "built in" by this exclusive BJ Pre-Setting Ring. Anyone with a wrench and a screwdriver now can perfectly install or replace BJ Mechanical Seals. No measurements, no installation drawings, no field fitting required.

This new development provides a seal *assembled as a cartridge unit*—ready for installation. The BJ Pre-Setting Ring is attached to the shaft sleeve collar with a set screw in a slot of controlled length.

You simply slip the "packaged" seal on the shaft and into the stuffingbox... bolt the seal flange to the stuffingbox and the shaft sleeve collar to the shaft... then move the Pre-Setting Ring the length of the set screw slot and lock in place. Your seal is now in precise running position with the spring compressed to its proper tension.

Save time and labor on initial seal installation and on periodic pump inspections. *Specify BJ Mechanical Seals with exclusive Pre-Setting Ring.*

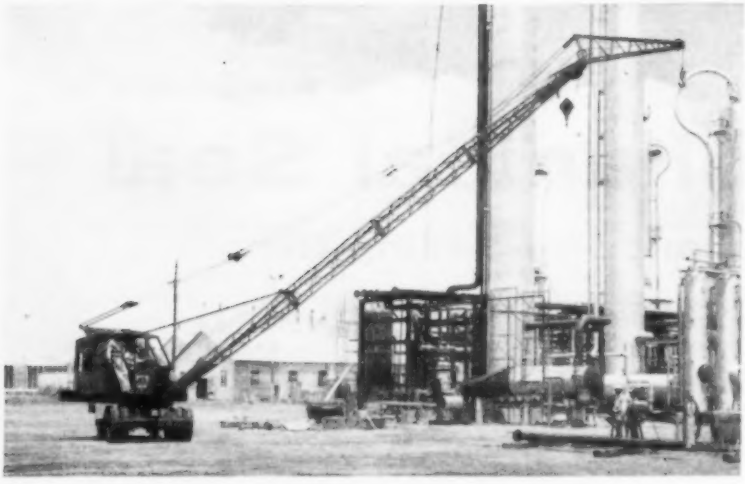
BJ

Byron Jackson Pumps, Inc.

A Subsidiary of Borg-Warner Corporation

P.O. Box 2017A, Terminal Annex, Los Angeles 54, California

Speedy **BANTAM**



- great "handy man"
- best for refinery construction and maintenance jobs

Whether it's trenching, backfilling, erecting steel, cleaning ditches, digging sump pump holes, installing or handling pipe—on dozens of tasks around refineries—the versatile, fast-moving BANTAM is your most efficient, low-cost rig.

High mobility on crane carrier mounting means that you can go anywhere—fast. Nine different quick-change attachments mean you can answer practically any need for digging —or for lifting loads of 6 and 7 tons. As a crane it gives you safe, precise handling with the ability to "inch" loads into position. Boom lengths available up to 45 feet; power up boom and power controlled lowering is standard.

Refinery users tell us that BANTAM works many places where other rigs can't go. Yet, with all its multi-purpose uses, BANTAM's low cost makes it the most competitive rig on the market. It not only costs less to buy, but less to operate, less to maintain. And it's reliable—the most job-proved machine of its kind.

See your BANTAM distributor or write us for details. Use the handy coupon below.

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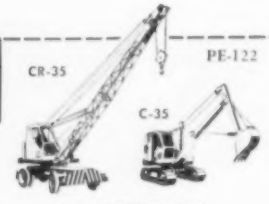

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WORLD'S LARGEST PRODUCER OF TRUCK CRANES AND EXCAVATORS

model or photos of the model are used by construction to erect the piping.

Piping Arrangement Model

This model has been experimented with to eliminate piping arrangement drawings and to serve as a basic check of the spool drawings.

Equipment for this model is made from approved vendors' drawings. As each pipe spool is drawn, it is fabricated in wire or plastic by the model makers and installed on the model. If the piece fits, the spool is basically correct as to orientation and its basic configuration. The spool drawings are then given a fractional dimensional check and issued for fabrication. We believe this method, when fully perfected, will utilize models to their greatest advantage.

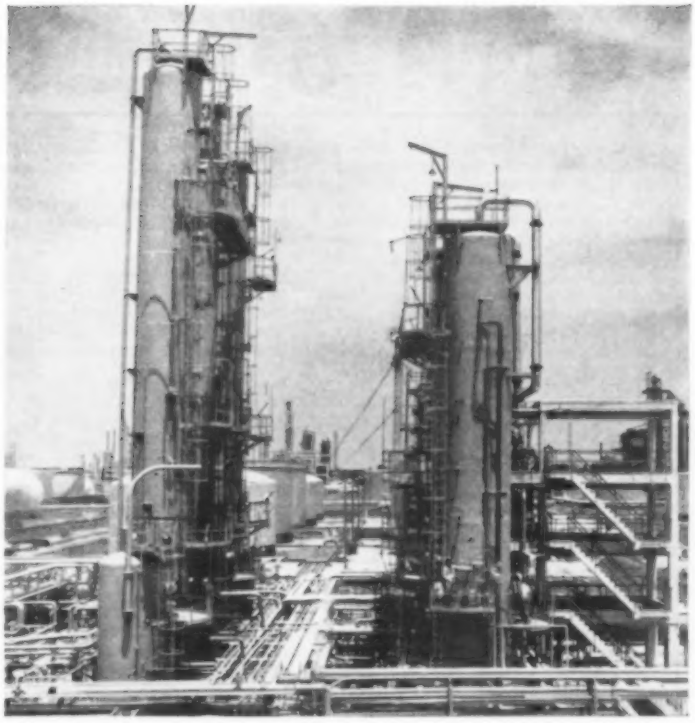
Conclusion

The use of models to the point where we can say they more than justify their costs has not happened over night. We have been experimenting with them for over five years. The first two or three years were somewhat unproductive as far as definitely pinning a dollar value on their worth. It has only been in the last year or so that we have been able to assign an approximate dollar mark to their savings.

Introducing the use of models has not been an easy task, however. The use of models in place of drawings runs contrary to too much tradition for the majority of draftsmen and plant designers.

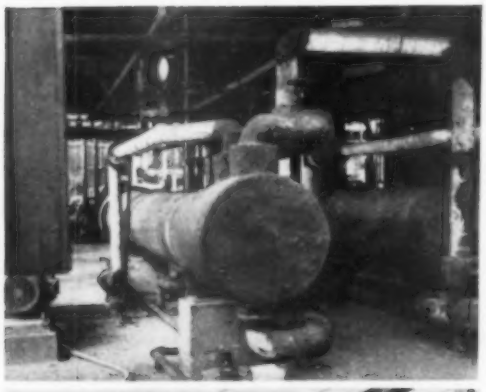
We should strongly advise any company contemplating using models as a design tool not to try forcing the use of models upon their designers. We recommend that the first attempts at using this tool be assigned to the highest qualified designers available. Our experience has indicated, that one of the strongest objections to models a designer has, is that his design will be open to the view of any casual observer. Consequently, a top notch man, who knows his design has no failings, will take to the use of models more readily than a less experienced man will. After the first few jobs, the converting of less experienced designers becomes a simpler chore.

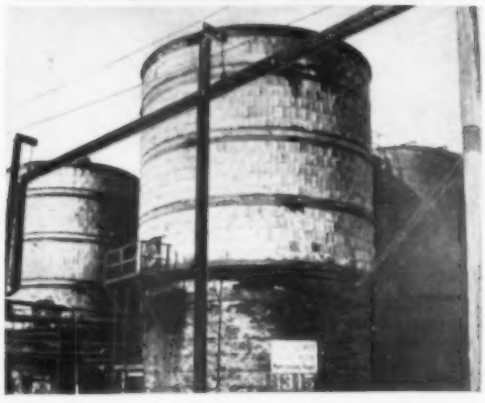
We feel that the many advantages we have achieved through the use of design models are just a beginning. Certain disadvantages of the model technique are acknowledged and methods of overcoming these disadvantages are being devised. No one is making any drastic statements about the elimination of the drawings altogether. But we are predicting greater savings, improved communication and better designs through continued and expanded use of design models. ★ ★ ★



Take towers — This one is saving a large southern refinery $20,000 a year in maintenance costs. Solid 7 16-in. Monel* nickel-copper alloy walls save the caustic stripping tower in the refinery's Unisol unit from the corrosive bite of 47° Baume caustic at 290° to 300°.

Experience spurs use of Monel for handling caustics





Heat exchangers (left) — Here's a preheater that is exposed to contaminated caustic entering the regenerator tower and to pure caustic leaving. Despite severe conditions, the preheater is giving trouble-free service. Shell and tubes are Monel alloy.

Agitators (lower left) — In this large agitator tank at an eastern refinery, bottoms and sides up to 6 ft. were replaced with Monel alloy. A wise choice. Monel alloy has proved to be the most economical material to use for this service.

Experience like this has led to the use of Monel alloy for a variety of other caustic processing units: reboiler tube bundles, hot caustic lines and caustic storage vessels, to name a few. In petrochemical plants using caustics, Monel alloy guards product purity.

Making available field experience in overcoming caustic corrosion is one of Inco's many services. Why not take advantage of this service? Send us details of your problem and our Research and Development Engineers will work with you to provide a solution.

*Registered trademark

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street New York 5, N. Y.

INCO Nickel Alloys

Monel ... *for minimum maintenance*

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REFINING AND PETROCHEMICAL

PERSONALS

▸ Wilshire Oil Company of California has announced the following staff appointments. **H. A. Vind,** formerly with the Union Oil Company, has been made general manager of branded products; **D. C. Lance,** formerly with Axelson Manufacturing Company, manager wholesale sales; **C. P. Taylor,** coming from Pan Am Southern Corporation, manager asphalt sales; **Dr. R. W. Michaels,** recently with Standard Oil Company of Indiana, has been appointed director of research.

▸ **Roy J. Diwoky,** widely known executive with more than 20 years service in the oil industry has been employed by the Commonwealth Oil Refining Company, Inc. At the annual stockholders meeting, he will be proposed for election as a director. At the organization meeting of the board of directors following the stockholders meeting it is planned to elect Diwoky president. He recently resigned as general manager of manufacturing and as a member of the board of directors of the American Oil Company.

R. J. Diwoky

▸ **C. L. Parris,** chief engineer at the El Dorado, Arkansas, refinery of the American Oil Company, has been named manager of the new plant for the midwest area for Amoco Chemicals Corporation.

▸ **Edmund Field** has been appointed senior research associate and **Herbert N. Friedlander** has become group leader at the Whiting, Indiana, laboratories of Standard Oil Company (Indiana). Dr. Field will coordinate work on olefin polymerization related to high polymers. Dr. Friedlander will continue work on polymerization.

▸ **T. J. Oleszko** of Aurora Gasoline Company has been promoted to manager of the company's newly established technical service department. The following company engineers have been assigned to this department: **R. McCord, W. W. Gotshall, C. J. Ryskamp, H. Doron,** and **S. J. Singer.**

R. W. Sheets has been appointed manager of Aurora's economics and yield department. **L. Mihaly** has been appointed special engineering assistant to this department, and the department's yield section will be headed by **R. Hendry.**

▸ **Charles A. Schrader** has been named vice president for supply and transportation at Leonard Refineries, Inc. He formerly was president and a director of Michigan-Ohio Pipeline Corporation in Mt. Pleasant, Michigan.

▸ Ethyl Corporation has formed a separate engineering department. It will be headed by **A. C. Burdick,** as chief engineer, **G. S. Roberts,** director of general engineering, and **J. B. Rhorer,** superintendent of construction coordination.

▸ Two new vice presidents have been elected by Brown & Root, Ltd. They are **W. Hurd Manahan,** who has been promoted to vice president in charge of construction; and **Wayne E. Williams,** the new vice president in charge of design engineering and sales.

▸ **Dr. Morton J. Fainman,** formerly senior project chemist for the Standard Oil Company of Indiana, has been named executive engineer for the Cobalt 60 project of the Cook Technological Center, Morton Grove, Illinois.

▸ **John W. Newton,** vice president and manager of Magnolia Petroleum Company's refining division at Beaumont, Texas, is retiring May 1. He started with the firm as a chemist 43 years ago.

▸ **Charles L. Thomas,** director of research and development of the Sun Oil Company, Marcus Hook, Pennsylvania, has been elected a director-at-large of the American Chemical Society. He will serve on the board through 1958, completing the unexpired term of **Dr. Clifford F. Rassweiler,** who became a director ex-officio when he was named president-elect of the society. Dr. Rassweiler is vice chairman of the board and vice president for research and development of the Johns-Manville Corporation, New York.

▸ Five promotions in the Paulsboro, New Jersey, manufacturing department of the chemicals division of Houdry Process Corportation have been announced. **N. B. Latham,** general foreman, was named superintendent in charge of the services section; in the engineering and development section, **H. G. Vernon,** mechanical engineering section designer, became plant mechanical engineer; **D. E. Field,** technical assistant to the plant manager, was named plant development engineer; in the production section, **W. R. Graves** moved up from shift foreman to production foreman, and was succeeded by **C. A. Bratton, Jr.**

▸ **K. V. Doughty,** manager of supply for Tuloma Gas Products Company, has been elected to the company's board of directors. He has been with Tuloma since the company's formation in June, 1954. He came from Pan American Petroleum Corporation, then called Stanolind Oil and Gas Company.

▸ **Fred A. L. Holloway** has been named an assistant general manager of manufacturing, Esso Standard Oil Company. He has been general manager of the East Coast division of Esso's manufacturing department.

▸ **Dr. Michael J. Rzasa** has been appointed manager of the company's new product research laboratory at Cranbury, New Jersey. **Fred Merliss** has been made assistant manager of the exploration and production laboratory at Tulsa, Oklahoma. **B. H. Rosen** of the New York office will be in charge of all product development at the Cranbury laboratory. **Dan Milsom** is being transferred from the Lake Charles laboratory to Cranbury where he will be in charge of radiation research.

▸ Commercial Solvents Corporation has elected **J. F. Dudley** and **Graham W. McMillan** as vice presidents. Prior to his present assignment, Dudley was CSC's chief engineer. McMillan was manager of development.

▸ **William G. Copeland** has been appointed general manager of The Texas Company's refining department.

Copeland, manager of the refining department's operation division succeeds **Theodore A. Mangelsdorf,** who recently was elected a vice president. **Douglas P. Bailey,** assistant works manager of the company's Port Arthur, Texas, refinery, succeeds Copeland.

The Texas City, Texas, refinery of American Oil Company was the scene of a recent two-day engineering conference which brought together for the first time since the merger of Pan-Am Southern Corporation into American Oil Company, representatives of the company's six refineries. Part of the group of the company's refinery engineers are shown listening to S. B. Schapiro (far left), manager of engineering, construction and maintenance, explain a modernization project at the refinery. Others are (left to right): A. L. Moore, mechanical superintendent, Baltimore, Maryland; R. B. Sykes, chief refinery engineer, Destrehan, Louisiana; P. E. Darling, assistant manager of engineering, Texas City; J. M. Considine, design engineer Savannah, Georgia; C. J. Houlgrave, chief refinery engineer, Texas City; R. H. Koehler, director of general engineering, Texas City; P. J. Hurd, chief refinery engineer, Yorktown, Virginia; and W. C. Harbison, chief refinery engineer, El Dorado, Arkansas.

NEW Refining Equipment

• machinery • supplies • services

For more information on items described here in brief, use the handy reply card and circle the corresponding numbers

Steam Valve Features Built-in Strainers. A pressure reducing and regulating valve for steam service featuring built-in pilot and main valve strainers, Cash Standard type 44, is a single seat, internal pilot-operated, piston-actuated model. It is highly sensitive and responsive to the smallest changes in reduced pressure. The strainers reduce maintenance to a minimum over long periods of service, and are easily removable for cleaning or replacement without removing the valve from the line. *A. W. Cash Company.*

Circle number (41) on reply card.

New 2000 Psi Vane Pump. Series of balanced vane hydraulic pumps for continuous 2000 psi service has been introduced by the Denison Engineering Division, American Brake Shoe Company. The "T" series pumps feature hydraulically balanced vanes and are offered with deliveries of up to 100 gal per min at speeds up to 1800 rpm.

Two bolt threaded flanges are provided as standard equipment but four bolt hydraulic connections are available for those desiring to use SAE four bolt split flange connectors. A nose type shaft seal, designed to withstand inlet pressures up to 100 psi gage, provides a positive type seal with considerably longer life than the lip type seal. This pump may be face, foot or flange mounted in any of four positions on its mounting bracket. The suction inlet port can be assembled in many selected positions with regard to the pressure delivery port. *Denison Engineering Division, American Brake Shoe Company.*

Circle number (42) on reply card.

Epoxy Coatings Protect Surfaces. Protection for surfaces and finishes exposed to corrosives and weather conditions is promised by 2 new coating resins. Used outdoors as well as indoors, Maraset grey enamel No. 750 and clear varnish No. V-760 are flexible yet highly abrasion-resistant. They withstand a wide range of chemicals, including acids, alkalies, caustics, and solvents. Without softening or buckling even under high heat and extreme humidity, they adhere firmly to wood, metals, concrete, plaster, paper, and plastics. *Marblette Corp.*

Circle number (43) on reply card.

Indicating Tape for "Hot Liquid" Lines. A plastic indicating tape for wrapping acid and caustic transport pipelines has been developed by Neirad Industries, Inc. of Darien, Connecticut. Plastic tape is wrapped around pipelines and will indicate by a discoloration of the tape anywhere a leak or "weep" developes. Used primarily in areas where leaking acid or caustic would be a hazard due to passenger personnel, tape is made of fiber glass with a vinyl covering and coated with a patented indicator. Acid lines are covered with a red colored indicator that turns yellow with acid. A white colored tape is used for caustic lines and leakage of caustic liquid turns the color purple. *Neirad Industries, Inc.*

Circle number (44) on reply card.

Non-skid Gratings and Treads. "Relgrit" trade names a new design of non-skid gratings and treads in which a non-absorbent hard and tough abrasive is baked into V-shaped openings made along the top surfaces.

The abrasive presents a non-skid surface that is not subject to attack by chemicals. It remains effective in the presence of oil and water as well as when the surface is dry. The abrasive stands a little above the top surfaces of the bars and is embedded about ⅛ in. in depth. Catalog R-655. *Reliance Steel Products Company.*

Circle number (45) on reply card.

Liquid Ejector. Selas Liqui-Jector, a liquid-gas separation device for removal of entrained liquids and solids from air, gas and steam systems, is available in 12 sizes. It completely removes suspended liquid (water, oil and emulsion) and solid particles from process and instrument gas supply lines. The Liqui-Jector operates by phase separation; trapping solids, and passing liquid in one direction and gas in another, without interrupting the flow through the line. *Selas Corporation of America.*

Circle number (46) on reply card.

Valves With Integral or Renewal Seats. Bolted bonnet steel valves in globe, angle, check, "Flocontrol" and high pressure drop designs are available with either integral hard-faced or renewable stainless steel seats. Designed as a companion to the manufacturer's Type 950 800 psi steel gate valves, new 600 psi bolted bonnet valves are designed to service public utility, petroleum, chemical and other industries. Sizes are from ¼ in. thru 2 in. *Manning, Maxwell & Moore, Inc.*

Circle number (47) on reply card.

Valve Body Lengthened. Longer end-to-end dimensions on cast steel gate valves for butt welding are used by Crane Company. The increase applies to Crane's 150 lb cast steel gate valves in sizes from 2 in. through 24 in., which find many uses in the power plant, petroleum, and chemical processing industries among others. Increase in dimension would offer greater protection to seating areas against heat distortion during the welding of line connections. Longer dimensions comply with proposed ASA Standard B16.10. *Crane Company.*

Circle number (48) on reply card.

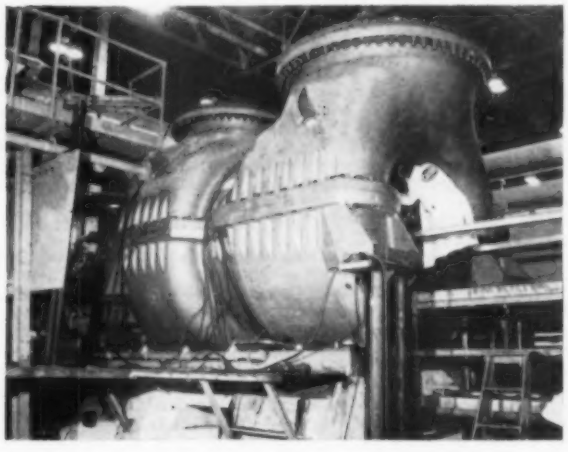
Big Axial Compressors for Synthetic Rubber. First of 2 giant axial flow compressors to be used in a Houston chemical plant for production of butadiene has been manufactured by Carrier. Each axial will serve as first stage in a 3-step compression process in a new Houdry dehydrogenation plant for Petro-Tex Chemical Corporation. Capacity is 172,500 cu ft of gas per min. Over-all dimensions are 11 ft high, 16½ ft long and 10½ ft wide. In the center shaft area between the 2 lobes is a 12-stage axial compressor which will be driven by a 4500 hp steam turbine. (Left below.) *Carrier Corporation.*

Circle number (49) on reply card.

400-Cycle Induction Heating Unit. Unit offers several distinct advantages to welders.

It permits preheating and stress relieving to be carried out economically in one continuous cycle without necessity of moving the weldment for furnace treatment or other operation. When the preheat temperature has been selected, the controlling instrument heats to this temperature and holds it accurately until welding begins. After the weld is completed, the instrument automatically starts the desired stress relieving program. (Right below.) *Hobart Brothers Company.*

Circle number (50) on reply card.



NEW Literature

For more information on items described here in brief, use the handy reply card and circle the corresponding numbers

Compressor Line. A new, 16-page bulletin, showing a complete line of small, air-cooled compressors for industrial, commercial and general use is offered by Gardner-Denver. Compressors described are widely used for a variety of jobs. Models shown include bare compressors and those with horizontal and vertical tanks. A popular trailer model used extensively by contractors, utilities, and industrial plants is included. *Gardner-Denver Company.*

Circle number (51) on reply card.

Pipe Hangers. A 16-page brochure describing Navco Counterpoise Pipe Hangers has been issued by National Valve and Manufacturing.

Booklet gives complete specifications for the entire line of hangers, engineering drawings of all models, weight-load selection tables, and erection and adjustment information.

Navco Levelglide Hangers, which permit horizontal movement of piping systems, are also described. *National Valve and Manufacturing Company.*

Circle number (52) on reply card.

Condensed Catalog. Two pieces of literature, a Condensed Catalog and a new Service Guide, have been published by McDonnell & Miller.

The Condensed Catalog is the latest edition of a catalog long familiar to the heating industry, this time less condensed than before, having grown from 4 to 8 pages. The McDonnell Service Guide is a brand new publication aimed toward better care and maintenance of McDonnell products in the field. It is small in size to fit handily in pocket or service kit. *McDonnell & Miller, Inc.*

Circle number (53) on reply card.

Bichromastic Analyzer. A new brochure on its Bichromator Analyzer is available from the instrument division of Perkin-Elmer. The Bichromator Analyzer is a dispersive infrared plant instrument for continuous, single-component measurement (either gas or liquid). *Perkin-Elmer Corporation.*

Circle number (54) on reply card.

Refractometers. Bulletin R 1000 describes 8 new refractometers for use in laboratory, pilot plant, and process control. It lists applications, sensitivities, ranges, and other important engineering data pertaining to the design and use of refractometers. *Phoenix Precision Instrument Company.*

Circle number (55) on reply card.

Plastic Rod and Tube Stock. A 24-page, two-color catalog on plastic rod and tube stock has been issued by Friedrich & Dimmock.

Publication covers the available sizes and prices of rod and tube stock made of crystal clear methyl methacrylate, Teflon, cast acrylic, vinyl, polyethylene, cellulose acetate, and polystyrene. *Friedrich & Dimmock, Inc.*

Circle number (56) on reply card.

Compressors and Turbines. Compressors, gas turbines, and power recovery turbines for the petrochemical and process industries are described in a 6-page brochure issued by Clark Bros. Among the photos are some showing the compressors and turbines in action. *Clark Bros. Co., one of the Dresser Industries.*

Circle number (57) on reply card.

Steel Container Directory. A 1956-1957 directory of steel shipping container manufacturers, covering by volume 95 per cent of total industry production, has been published by the Steel Shipping Container Institute.

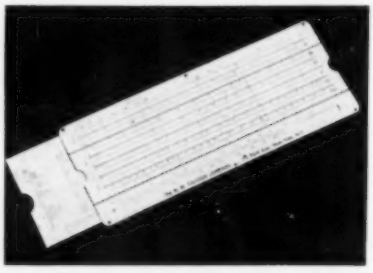
In the new directory are tables providing quick product-manufacturer cross-reference and addresses for manufacturers' plants and offices; statistics on annual production of various container types and their uses by industries; historical material; general information on container specifications and recommended universal standards; and recent developments in container design and in coating research. *Steel Shipping Container Institute.*

Circle number (58) on reply card.

Insulation Charts. As an aid to estimating the amount of material necessary to insulate cylindrical vessels, Armstrong Cork has developed a chart for converting gallon quantities into square feet of surface area. The chart was developed to eliminate complex mathematical calculations when vessels, such as domestic hot water tanks and expansion tanks, are designated only by gallon size, or by length and diameter. *Armstrong Cork Company.*

Circle number (59) on reply card.

Tool for Making Fast Equilibrium Flash Calculations. A new equilibrium-flash sliderule, developed by the Process Engineering Department of The M. W. Kellogg Company, enables engineers to make flash, bubble point and dew point calculations in less time. Sliderule is based on a newly developed method which converges toward the final solution more rapidly



than the conventional calculation routine. It makes it possible to cover a wide range of percent vapor and equilibrium constant values without losing accuracy.

Method was developed through Kellogg's constant review of mathematical tools used in process and design engineering. Conventional half-graphical method of flash calculation was found inadequate, new method was evolved which is capable of rapid performance.

Qualified engineers should write on company letterhead to The M. W. Kellogg Company, 711 Third Ave., New York 17, N. Y. Please Note: As presented in THE REFINING ENGINEER.

Tube Expander and Tube Cutter. Completion of an all-new catalog has been announced by Gustav Wiedeke.

This 32-page catalog contains complete specifications of the entire product line of Ideal Tube Cutters and Expanders, plus all necessary information pertaining to a complete line of operating accessories. *The Gustav Wiedeke Company.*

Circle number (60) on reply card.

Cutting. Development and applications of aircomatic cutting, a new method for straight line and shape cutting of nonferrous metals is described in a new 24-page informational pamphlet and catalog by Air Reduction Sales Company. New method, employing standard Aircomatic® welding equipment for manual and machine cutting, is particularly applicable for high-speed cutting and shaping of plates and parts to be joined by gas-shielded arc welding. *Air Reduction Sales Company.*

Circle number (61) on reply card.

Nafil Resin. Chase Chemical has released a new 6-page folder describing its Nafil resin for making polyurethane foam. Nafil foam can be produced in various densities and consistencies by mixing a Nafil resin and the correct catalyst. The 2 components can be mixed by hand or by machine and can be spray or pour applied. *Chase Chemical Corporation.*

Circle number (62) on reply card.

Boiler Tube Expander Control. Bulletin 56-1, published by Thomas C. Wilson, describes the Model C Torq-Air-Matic air-powered boiler-tube expander drive and control. The advantages of precise tube rolling are discussed and the features of the new device enumerated. *Thomas C. Wilson, Inc.*

Circle number (63) on reply card.

Compressor Lubricants. Pydraul AC, a fire and explosion resistant fluid developed by Monsanto specifically as a lubricant for air compressors, is the subject of a technical bulletin. Use of the fire-resistant fluid in place of petroleum oil greatly reduces hazards of air compressor explosions and receiver fires, the bulletin states. *Monsanto Chemical Company, Organic Chemicals Division.*

Circle number (64) on reply card.

Thermocouple Insulators. Claud S. Gordon has issued a bulletin illustrating and describing the complete line of Serv-Rite thermocouple insulators.

Listed are the dimensions, sizes, and types of insulators available for high thermal shock, high temperature, and high mechanical strength. Principal properties of the different materials are included as an aid in selection. *Claud S. Gordon Company.*

Circle number (65) on reply card.

Glass. Manufacturing methods, applications, and the history of glass are explained in a colorful brochure. Entitled *"This Is Glass,"* publication deals with such topics as what is glass, how is glass made, and how is glass used. *Corning Glass Works.*

Circle number (66) on reply card.

Catalog of Industrial Insulating Materials. Full specifications for complete line of spun mineral wool industrial insulating products are presented in a new catalog. Catalog lists standard sizes, thicknesses, and thermal conductivities for more than 20 types of heat and cold insulations for equipment and piping. *Engineering Department, Baldwin-Hill Company.*

Circle number (67) on reply card.

How to cut line-up and welding costs by 20%

Lining up and welding sections of a pipe line costs a lot of money. But here's how Armco Welded Steel Pipe can help you reduce these costs as much as 20 per cent.

Armco Line Pipe is supplied in standard 50-foot lengths instead of the usual 40-foot or double-random lengths. This means at least 20 per cent fewer field joints. Line-up and welding time is reduced and you have fewer sections to handle.

What's more, the wide range of diameters—6 to 36 inches—and wall thicknesses—$\frac{9}{64}$ to $\frac{1}{2}$-inch—available in Armco Pipe lets you use exactly the right size for your particular requirements.

Use Armco Welded Steel Pipe for requirements in the Natural Gasoline and Natural Gas Divisions and wherever else you need dependable line pipe. Write for data. Armco Drainage & Metal Products, Inc., Welded Pipe Sales Division, 4317 Curtis Street, Middletown, Ohio. 201 KOME Building, Tulsa, Oklahoma. Subsidiary of Armco Steel Corporation. Export: The Armco International Corporation.

Armco Welded Steel Pipe

ARMCO

Digging range: Depth to 5'6". Width 19½" to 30".

a new advance for heavy-duty digging . . .

Barber-Greene Wheel Ditcher

This new development is Barber-Greene's latest addition to the four outstanding ditchers in the field.

Pace-setting features include:

New digging-wheel differential and split =1 shaft assure constant gear tooth contact on both sides of wheel . . . equalize torque . . . eliminate uneven stresses.

New flexible connection between chassis and boom eliminates excessive strain, twist and tilt on curves.

New Hydra-Crowd assures optimum digging speeds through independent, finger-tip control of crowding speeds—infinitely variable without shifting gears.

New electric overload release — provides overload protection without adjustment.

New all-hydraulic spoil conveyor— instantly reversible — operates independently of wheel. Infinitely variable speed to 650 f.p.m. permits accurate placement of spoil alongside ditcher.

New hydraulic controls — including hydraulic brakes — make operation easier, more accurate.

Advance models of this new Barber-Greene ditcher have already established a reputation for superior performance under the most grueling conditions.

Write for information on this newest ditcher in the Barber-Greene line of advanced design.

57-1-D

Barber-Greene BG

AURORA, ILLINOIS, U.S.A.

CONVEYORS . . . LOADERS . . . DITCHERS . . . ASPHALT PAVING EQUIPMENT

PIPELINE DEVELOPMENTS ★ ★ ★

Roundup of Planned and Proposed Construction

The following tables list the company, mileage, pipe size, and location of proposed pipeline projects — crude, products, and natural gas — reported to *The Pipeline Engineer*. Company addresses are given when known.

CRUDE LINES

Name of Company	Miles	Size	Location
Cape Pipe Line Company Philadelphia, Pennsylvania	200	—	Large diameter from Delaware Bay to Greater Philadelphia area refineries
Four Corners Pipe Line Company	750	8, 12, 16	Farmington, New Mexico, area to Los Angeles, California
Interprovincial Pipe Line Company Toronto 1, Ontario, Canada	151	20	Sarnia to Port Credit, Ontario
Lakehead Pipe Line Company, Inc. Toronto 1, Ontario, Canada	80	26	Loop from Clearbrook, Minnesota, to Superior, Wisconsin
North-West Oil Pipelines Company	210	—	Wilhelmshaven, on the North Sea, to industrial Ruhr area of West Germany
Northwest Pipe Line Corporation Salt Lake City, Utah	350	8–10	Four Corners area to Salt Lake City, Utah
Offshore Gathering Company Houston, Texas	364	20	Gulf of Mexico from Sabine Pass to Mississippi River
Rangeland Pipe Line Company Calgary, Alberta, Canada	450	—	Sylvan Lake Area to Sundre (Central Alberta)
Royal Dutch Shell Group and Others The Hague, Netherlands	870	30	Marseille, France, to Rotterdam, Holland, and Antwerp, Belgium
Royal Pipe Lines, Ltd. Regina, Saskatchewan, Canada	288	Var.	Cantuar area fields to Glenavon
Shamrock Oil and Gas Company Amarillo, Texas	35	6	5000-6000 bbl per day line from McKee station, Moore County, Texas, to Hansford and Ochiltree counties
Sinclair Pipe Line Company Independence, Kansas	150	20	Teague to Houston, Texas
Texas-New Mexico Pipe Line Company Houston, Texas	515	16	Extension from Jal, New Mexico, pump station to Four Corners area
Trans-Border Pipe Line Company	110	—	Skagway, Alaska, to Whitehorse, Yukon Territory

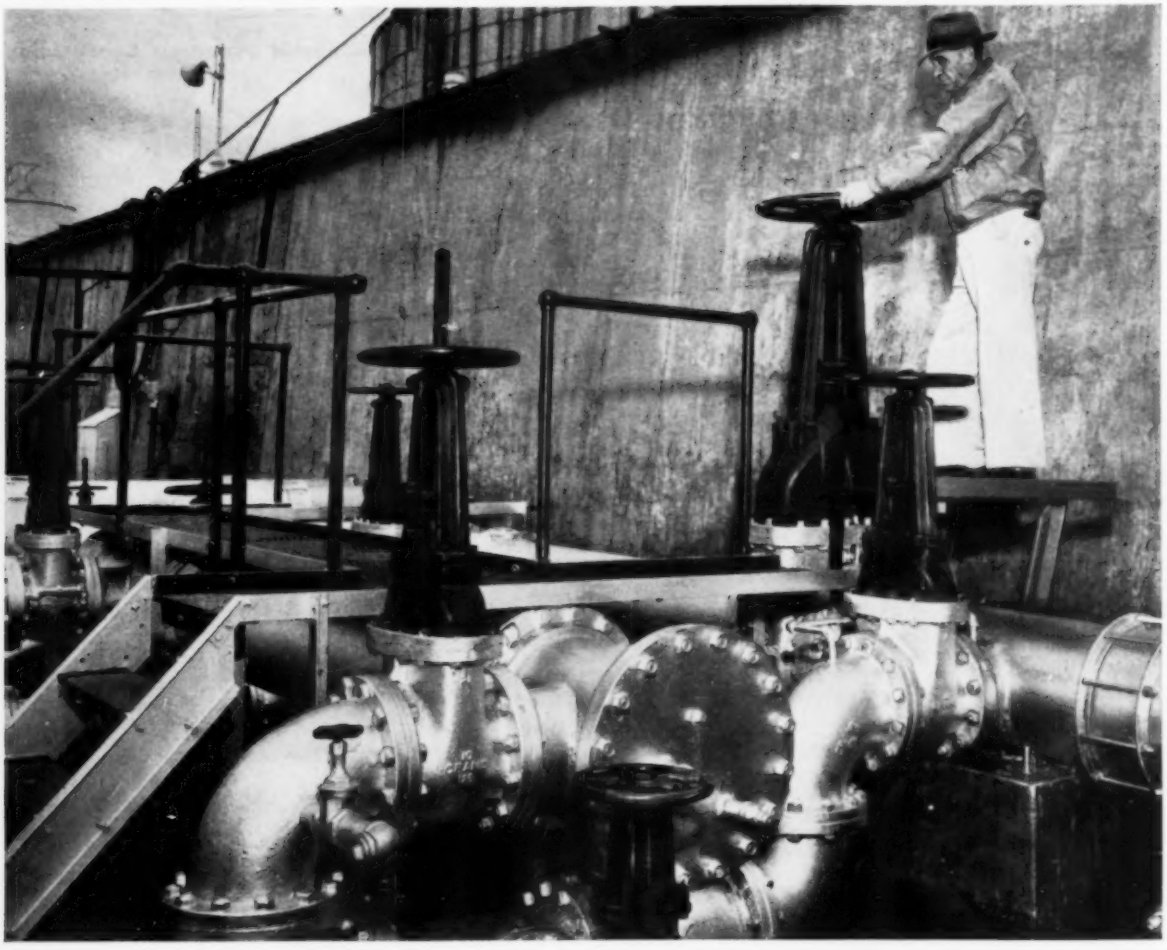
PRODUCTS LINES

Name of Company	Miles	Size	Location
El Paso Natural Gas Company	96.0	8	Gallup to Blanco Plant, New Mexico
El Paso, Texas	290	Var.	Additional line on existing system in Texas, New Mexico, Arizona
El Paso Natural Gas Products Company	250	6	Odessa, Texas, to El Paso
Equitable Gas Company and Subsidiaries Pittsburgh, Pennsylvania	100	4–5	Maytown, Kentucky, to Institute, West Virginia
Great Lakes Pipe Line Company Kansas City, Missouri	84	8	Eau Claire, Wisconsin, laterally from a point on existing lines south of St. Paul, Minnesota
	68	12	To Chicago from juncture of Great Lakes' lines with Badger system. Will supplant existing 6-in. line
Northwest Pipeline Corporation Salt Lake City, Utah	350	8–10	Four Corners to Salt Lake City, Utah
Ohio Oil Company	—	—	Common carrier line from Wood River, Illinois, to Chicago
Findlay, Ohio	—	—	Connecting line from Robinson, Illinois, refinery to new line
Service-Continental-Sinclair-Phillips	550	—	Salt Lake City, Utah, to Spokane, Washington
Texas Eastern Transmission Corporation Shreveport, Louisiana	1168	16–20	Conversion of "Little Inch" between Beaumont, Texas, and Moundsville, West Virginia
Union Oil Company of California	815	—	Shale Oil Plant, Rifle, Colorado, to Los Angeles area
Winnipeg & Central Gas Company Winnipeg, Manitoba, Canada	210	6	U. S.-Canadian border to Winnipeg

GAS LINES

Name of Company	Miles	Size	Location
Andes Pipeline Corporation	500	12	Villamontes, Bolivia, to Antofagasta, Chile
Cities Service Oil Company Bartlesville, Oklahoma	70	—	Gas gathering system on the Roberts Ranch, Midland, Texas

Another Performance Record for Crane Iron Body Valves



36 years in a busy marine terminal —these Crane valves never in need of repairs

Installed in 1920, the Crane iron body gate valves in this fuel oil suction manifold still have a cost-free service record. To date, not one has needed more than normal stuffing box maintenance.

The General Petroleum Corp. (owner of the installation) marine terminal in Seattle is a big, busy place—no "soft berth" for valves. The big valve, for example, is operated an average of 6 or 7 times daily. Yet, like all other valves in the manifold, it remains completely leak-free and trouble-free.

Outstanding performance? Yes, but not unusual for Crane iron body gate valves. You will find them scoring similar service records in every industry. They're strictly quality-made to give above-average performance at low ultimate cost.

Current model Crane 125-pound iron body gate valves with every desirable feature are available in patterns and sizes for all needs. Next time your Crane Representative calls, be sure to ask him about these valves. Or write to address below for complete information.

You may spot cost-saving ideas in this book of "Valve Performance Facts"—32 case histories throughout industry. Ask your Crane Representative or write for a copy.

CRANE VALVES & FITTINGS

PIPE • PLUMBING • KITCHENS • HEATING • AIR CONDITIONING

Since 1855 — Crane Co., General Offices: Chicago 5, Ill. — Branches and Wholesalers in All Areas

D-4

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

the INSLEY "pipeliner"

- Wide, deep carbody with removable bottom cover plates
- Crawler rollers and tumblers sealed against dirt
- Two speed travel (optional)—.8 M.P.H. and 1.6 M.P.H.
- Increased stability and flotation with 12′6″ crawlers and 24″ or 30″ shoes
- Long wearing, heat-treated alloy steel crawler shoes and pins
- Fully convertible for hoe, shovel, dragline, clamshell and crane
- Available with gasoline or diesel power

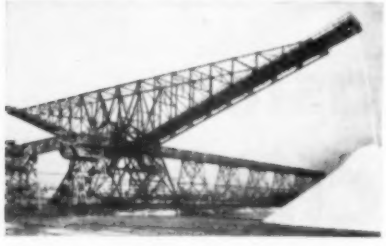
for further information, write:

INSLEY MANUFACTURING CORP. · INDIANAPOLIS, INDIANA
wholly owned subsidiary | **THE MAXI CORP. · LOS ANGELES**

THERE'S AN
INSLEY
WORKING NEAR YOU

Name of Company	Miles	Size	Location
Coastal Transmission Corporation	574	22–26	McAllen, Texas, to Baton Rouge, Louisiana
Dallas, Texas	414	Var.	Gathering lines in Rio Grande Valley, Texas
Colorado Interstate Gas Company	345	30	Kit Carson, Colorado, to Beatrice, Nebraska
Colorado Springs, Colorado	100	24	Springfield to Pueblo, Colorado
	24	24	Greenwood to Panhandle-Kit Carson loop
	109	20	Loop from Fourway, Texas, to Springfield, Colorado
	106	24	Loop from Springfield to Kit Carson, Colorado
	10	16	Keyes field, Oklahoma, to mainline
	6	10	Tablerock field, Wyoming, to mainline
	12.0	12–22	Additions in Texas Panhandle fields
El Paso Natural Gas Company	20.5	30	Loops to existing Permian-San Juan mainline from Bluewater station to San Juan mainline in McKinley County, New Mexico
El Paso, Texas	8.3	26	Loops to California mainline in Yuma County, Arizona
	28.5	30	Field transmission line in San Juan Basin, New Mexico
	78.8	18	Field line from Carson County, Texas, to Moore County, Texas
	22.5	20	South Andrews field booster station to plant
	8.5	16	Shell plant to Goldsmith station
	290	—	To deliver additional gas to three California customers. New gas to come from San Juan Basin and Panola and Permian Basin fields in Texas.
Houston Texas Gas & Oil Company	942.6	12–30	Baton Rouge, Louisiana, to Miami, Florida
Houston, Texas	682	—	Laterals to serve Florida to distributors, industrial users
Kansas-Nebraska Natural Gas Company	61.3	Var.	Gathering lines from Camerick field to Liberal, Kansas
Phillipsburg, Kansas			
Kansas-Nebraska Natural Gas Company, Inc.	10	10	Grand Island to Fullerton, Nebraska
Hastings, Nebraska	10	8	Loop from Grand Island to Fullerton, Nebraska
	11.5	12	Replacement from Scott City to Oakley, Kansas
	1.2	6	Additions to system in Nebraska
	9	8	Lexington to Central Nebraska Public Power Electric Plant
	14	16	Replacement from North Platte to Maxwell, Nebraska
Michigan Wisconsin Pipe Line Company	31	4–6	Looping in Michigan and Indiana
Detroit, Michigan			
Midwestern Gas Transmission Company	1112	12–24	Mainline from U. S.-Canadian border near Emerson, Manitoba — Noyes, Minnesota, to Portland, Tennessee
	648	3–18	Laterals of mainline to serve communities in Minnesota, North Dakota, and Wisconsin
Natural Gas Pipe Line Company of America	349	20–26	Jack and Wise counties to Fritch, Texas
Chicago, Illinois	38	36	Joliet to Elgin, Illinois
	405	36	Beaver County, Oklahoma, to Joliet, Illinois (loops)
	25	—	Gathering line from Quinduna field, Roberts County, Texas, to point on existing line
	91	30	Loops in Nebraska, Kansas, Oklahoma
Northern Natural Gas Company	28	24	Ogden to Redfield storage area, Iowa
Omaha, Nebraska	168	20	St. Paul-Minnesota to Duluth, Minnesota, and Superior, Wisconsin
	100	20–24	Savannah Creek field, Alberta, to Alberta-Montana border near Cardston, Alberta
Northern Plains Natural Gas Company (subsidiary of Northern Natural Gas Company)	1100	26	Alberta-Montana border to Minneapolis, Minnesota
Omaha, Nebraska			
Offshore Gathering Company	364	30	Offshore gas line in Gulf of Mexico from Sabine Pass to Mississippi River
Houston, Texas			
Pacific Gas & Electric Company	200	12	Glenn and Tehama counties to Eureka and Arcata, California
San Francisco, California			
Pacific Lighting Gas Supply Company	80	30	Coles Levee to Newhall, California
Los Angeles, California	2.1	16–20	Potrero to Newhall, California
	2.8	16	Lines in East Whittier, California
Tennessee Gas Transmission Company	100	—	New gathering lines in Texas and Louisiana
Houston, Texas	557	30	Mississippi River Delta south of New Orleans to Portland, Tennessee
	120	12,20,26	Kinder, Louisiana, south 68 miles into Gulf of Mexico
	332	24–30	Loops in Kentucky, West Virginia, Pennsylvania, Tennessee
	76	24	Coudersport, Pennsylvania, to Buffalo, New York
	299	Var.	Adding to existing systems in Ohio, Pennsylvania, Kentucky, Texas and Louisiana
Texas Eastern Transmission Corporation	10	12	Loop from Broadaxe Junction to Levick Street, Philadelphia, Pennsylvania
Shreveport, Louisiana	6	12	Loop from Broadaxe Junction to Conshohocken, Pennsylvania
	5	10	South Plainfield to Highland Park, New Jersey
Texas-Illinois Natural Gas Pipeline Company	59	20	Joliet to Volo, Illinois
Chicago, Illinois			
Trans-Canada Pipe Lines, Ltd.	1675	30–34	Winnipeg to Montreal and laterals
Calgary, Alberta, Canada			
Transcontinental Gas Pipe Line Corporation	28.5	16	Gathering system in Gulf of Mexico, off Louisiana Coast
Houston, Texas	229	—	Gathering laterals in Texas
	42	36	Loops on existing lines
	16	30	Additional mainline looping
Westcoast Transmission Company, Ltd.	174	30	Line from Savannah Creek gas field, Alberta to existing system

American Louisiana Pipeline, carrying natural gas 1000 miles from Louisiana to Michigan, was given the proven protection of coal-tar enamel coatings. Three different types of enamels were used on various sections: Bitumastic® No. 2 Enamel for application in mild climates, Bitumastic No. 70-B Enamel for application to portions subjected to colder weather, and Bitumastic Hi-Melt Enamel for hot sections of the line after compressor stations. There's a Bitumastic Enamel for every pipeline need, from hot-line coating to sub-zero conditions. Your Koppers representative will be glad to explain why coal-tar enamel is your best investment for long-lasting protection of pipelines.



19 Years of Protection were given this giant gantry crane at a salt-producing plant by a coating system of Bitumastic Super Service Black. Exposed to the corrosive combination of salt plus atmospheric moisture, the coating system has required only minor touch-up in all these years of service. Bitumastic Super Service Black is one of seven Bitumastic coatings; the complete line offers wide flexibility in the selection of corrosion-preventive materials to best meet the individual requirements of your application.

Corrosion Control in sewage and waste treatment plants is the subject of a new bulletin now available from Koppers. It contains complete engineering specifications for protective coating systems. Please request your copy on company letterhead from Koppers Company, Inc., Tar Products Division, 1455 Koppers Building, Dept. 105E, Pittsburgh 19, Pa.

how to
CUT CORROSION LOSSES
a report by Koppers Company, Inc.

Number 8 of a series

F. R. Charlton
Development Group Supervisor

An ideal coating possesses the ability to adhere tenaciously to a metal surface directly. Coal-tar enamels will provide such a bond when the surface is preheated. However, enamels applied directly to metal surfaces at normal temperatures chill too quickly and a poor bond results.

* * *

To overcome this problem, enamel primers of modified coal-tar pitch in suitable solvents were developed. When hot enamel is applied over a thoroughly dry, solvent-free pitch film, the primer melts slightly and produces a welded system—primer to pipe and enamel to primer.

The drying time of enamel primers is directly related to the volatility of the solvent and the environment. If hot enamel is applied to the primer before it is completely dry, the traces of solvent will destroy the bond to the enamel. Conventional practice is to prime one day and enamel the next, although this waiting period may be extended to several days or longer by poor drying conditions.

* * *

The Coatings Group at our Verona Development Laboratory recently studied this problem from a fresh point of view. They searched for a new base material, other than coal-tar pitch, which (1) would be compatible with the enamels, (2) would permit employing more volatile solvents, and (3) would provide a superior bond. After thorough study, a number of new formulations were tested. One met the requirements; it is called Bitumastic® Jet-Set.

Bitumastic Jet-Set is an entirely new kind of primer. It is formulated from special, plasticized resins which permit the use of low-boiling solvents and are compatible with coal-tar enamel. Bitumastic Jet-Set exhibits remarkably low temperature susceptibility and excellent resistance to chemical environments and moisture.

The drying rate of Bitumastic Jet-Set is truly amazing. It dries to touch in from 1 to 15 minutes and is ready for enameling in a maximum of 8 hours; conventional primers under similar conditions require several days to dry adequately.

* * *

Bitumastic Jet-Set opens up entirely new opportunities for the application of coal-tar enamel. Field experience has proved that the fast-drying characteristic of this new primer saves time and actually permits work to continue where heretofore, conventional primers have necessitated shutdown. Another application, where piling was driven after being enameled, demonstrated the excellent bonding ability of Bitumastic Jet-Set.

Complete data on this new primer is available. Ask your local Koppers representative, or write Koppers Company, Inc., 1450 Koppers Building, Department 105 E, Pittsburgh 19, Pa. District Offices: Boston, Chicago, Los Angeles, New York, Pittsburgh, and Woodward, Ala. In Canada: Koppers Products, Ltd., Toronto, Ont., and Edmonton, Alta.

KOPPERS

BITUMASTIC
REG. U. S. PAT. OFF.
COATINGS AND ENAMELS

This is one way to protect pipe lines from rust and corrosion but . . .

It's Easier and Cheaper with UNICOR®

UNICOR, UOP's oil soluble corrosion inhibitor, gives dependable protection at suprisingly little cost. Actually only one molecule of Unicor is required for every million molecules of pipe line product. Its cost is only about $0.0005 per barrel of product.

It's economical to apply, too. Addition is made at only one point and since it is distributed evenly over the entire internal surface, protection is virtually 100% effective. There are important additional savings, too, from reduced scraper cleaning and filter replacement costs.

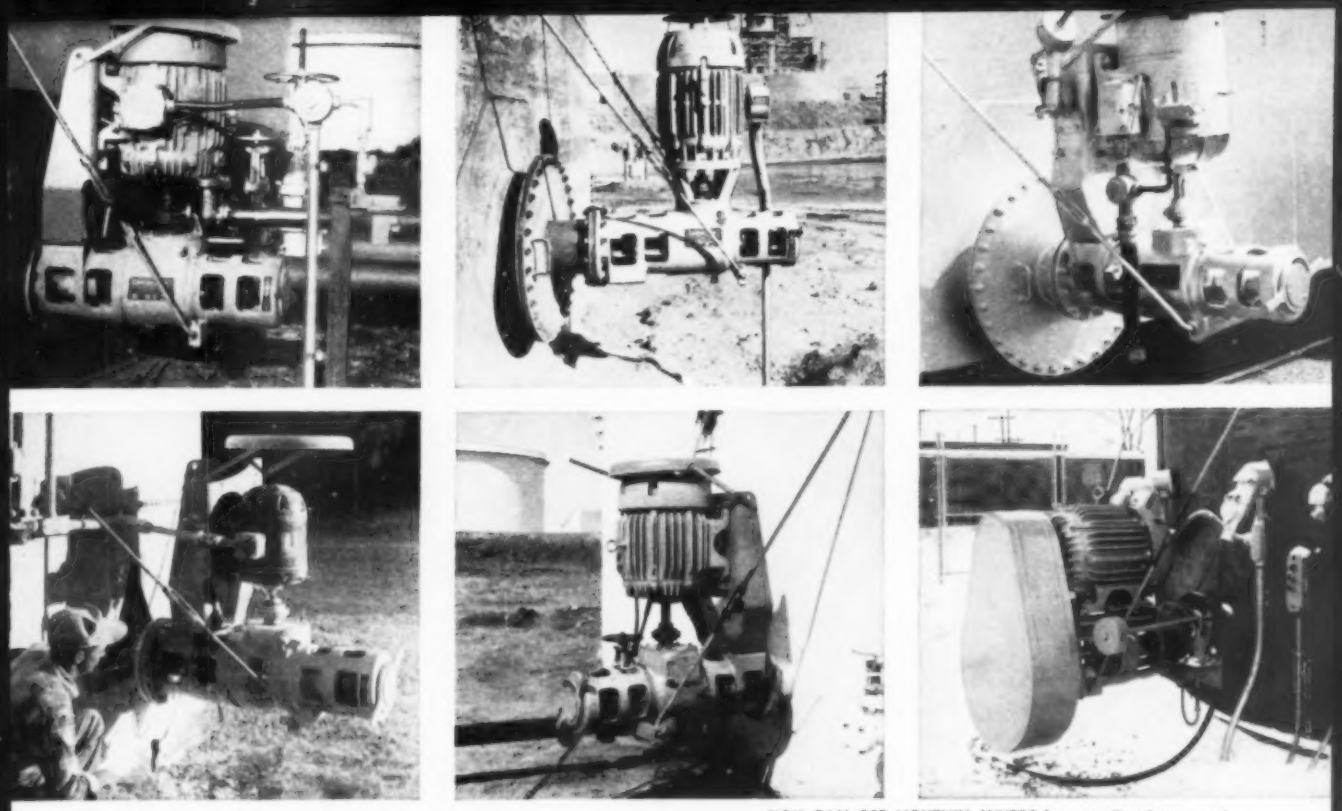
We will be glad to have our technical specialists assist you in the design, installation and operation of a Unicor system of protection.

UNICOR is one of a number of UOP inhibitors and additives available to the refining industry. If you have a protection or preservation problem for product or transport facilities consult us.

PRODUCTS DEPARTMENT

UNIVERSAL OIL PRODUCTS COMPANY

30 ALGONQUIN ROAD, DES PLAINES, ILLINOIS, U. S. A.



YOU CAN GET LIGHTNIN MIXERS for controlling bottom sediment in any tank, regardless of capacity.

How 50 pipe line companies keep tank bottoms clean . . . **by pressing a switch**

More than 50 independent pipe line companies, and some 35 leading producers and refiners, have found an easy way to say good-bye to sludge cleanout costs in crude storage tanks.

Uniform crude; no sludge pile-up; dramatic savings—these are the results when you control sediment by flipping the switch on a LIGHTNIN Mixer.

Saved: $1,000 per tank per year

If your tank cleaning costs are about average, you lose from $5,000 to $8,000 every time you clean out an 80,000-barrel tank. These cost figures include a conservatively estimated $2,000 in marketable oil and wax lost in the bottoms. Often, this loss runs much higher—as high as $6,000 in some cases.*

When you install LIGHTNIN Mixers, you eliminate sludge buildup for good. You can keep sediment suspended in the crude, or resuspend it if it has settled. You can blend crude stocks to prevent stratification, and to dispatch a uniform crude.

Savings, overall, are on the order of $1,000 per tank per year.

As a bonus, you keep full holding capacity of your crude tanks ready for use when you need it. You gain as much as 12% more storage capacity —without adding a single tank.

Your LIGHTNIN Mixer representative can tell you how much *you'll* save with LIGHTNINs in your crude storage tanks. Look him up in Composite Catalog and call him in. Or write us direct.

*Based on field studies by a major pipe line company. Details on request.

"Lightnin® Mixers"

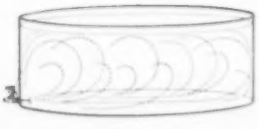
MIXCO fluid mixing specialists

Get these helpful bulletins on BS & W control and LIGHTNIN Mixers. Check, tear out and mail to us today with your name and company address. Free—no obligation.

- ☐ B-503 BS & W Control with LIGHTNIN Mixers
- ☐ B-104 Side entering mixers, 1 to 25 HP
- ☐ B-107 Data sheet for figuring mixer requirements
- ☐ B-109 Condensed catalog describing LIGHTNIN Mixers —all types
- ☐ B-111 LIGHTNIN rotary mechanical seals for extra-low-cost mixing

MIXING EQUIPMENT Co., Inc., 127-d Mt. Read Blvd., Rochester 11, N. Y.

In Canada: Greey Mixing Equipment, Ltd., 100 Miranda Avenue, Toronto 10, Ont.



YOU CAN MAINTAIN bottom sediment level of as little as one inch, year after year, with LIGHTNIN Mixers in your tanks.

NORDBERG

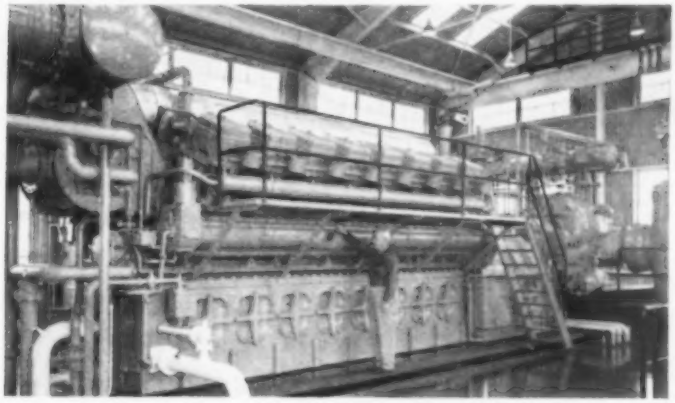
MEMO TO: Management
After investigation and full consideration of all facts this committee recommends the installation of Nordberg engines for this pipeline project.
Chairman, Technical Committee
Dick Carlton

The Scene: Office of the Vice President in Charge of Operations, major gas transmission company.

The Problem: Selection of engine compressor units for gas pipeline expansion.

Recommendation: Install Nordberg *Supairthermal*® gas engine gear sets driving centrifugal gas compressors.

The Reason: Because the Nordberg units can be installed with lower capital investment, and operated at lower cost per horsepower-hour.



Nordberg Supairthermal Engines are, by all standards, your best investment in modern prime movers for compact, economical, long term pipeline power. These powerful engines are built in both In-line and V-types, in sizes from 500 to 4,500 horsepower for Diesel, Duafuel® or Spark-Ignition Gas operation.

Consult Nordberg on your next expansion program.

NORDBERG MFG. CO., Milwaukee, Wisconsin

NORDBERG

DIESEL • DUAFUEL® AND SPARK-IGNITION GAS ENGINES

©1957, Nordberg Mfg. Co.

O157

KEEP COSTS DOWN *with help like this . . .*

- **TORQUE CONVERTER DRIVE . . . matches power and speed to job requirements automatically . . . cushions entire power train**
- **1,000-HOUR LUBRICATION INTERVALS for truck wheels . . . eliminate daily greasing . . . convert service time to profit time**
- **ONE-PIECE STEERING CLUTCH AND FINAL DRIVE HOUSING . . . insures perfect alignment, low maintenance, long life**
- **UNIT CONSTRUCTION . . . makes major service simple, fast**
- **ALL-STEEL BOX-A MAIN FRAME . . . provides full-length protection**

All pioneered and proved by Allis-Chalmers . . . five of dozens of basic advantages that can help you bid lower . . . get more jobs . . . make a profit when you're through. Now is the time to have them working for you. Allis-Chalmers, Construction Machinery Division, Milwaukee 1, Wisconsin.

ALLIS-CHALMERS *Engineering in Action*

For your vital control communications

DEPEND ON MICROWAVE

. . . by Westinghouse

Your pipeline operation is as efficient—and profitable—as its control communications system.

That simple fact emphasizes the importance of a properly designed system to insure unfailing reliability and flexibility for future growth.

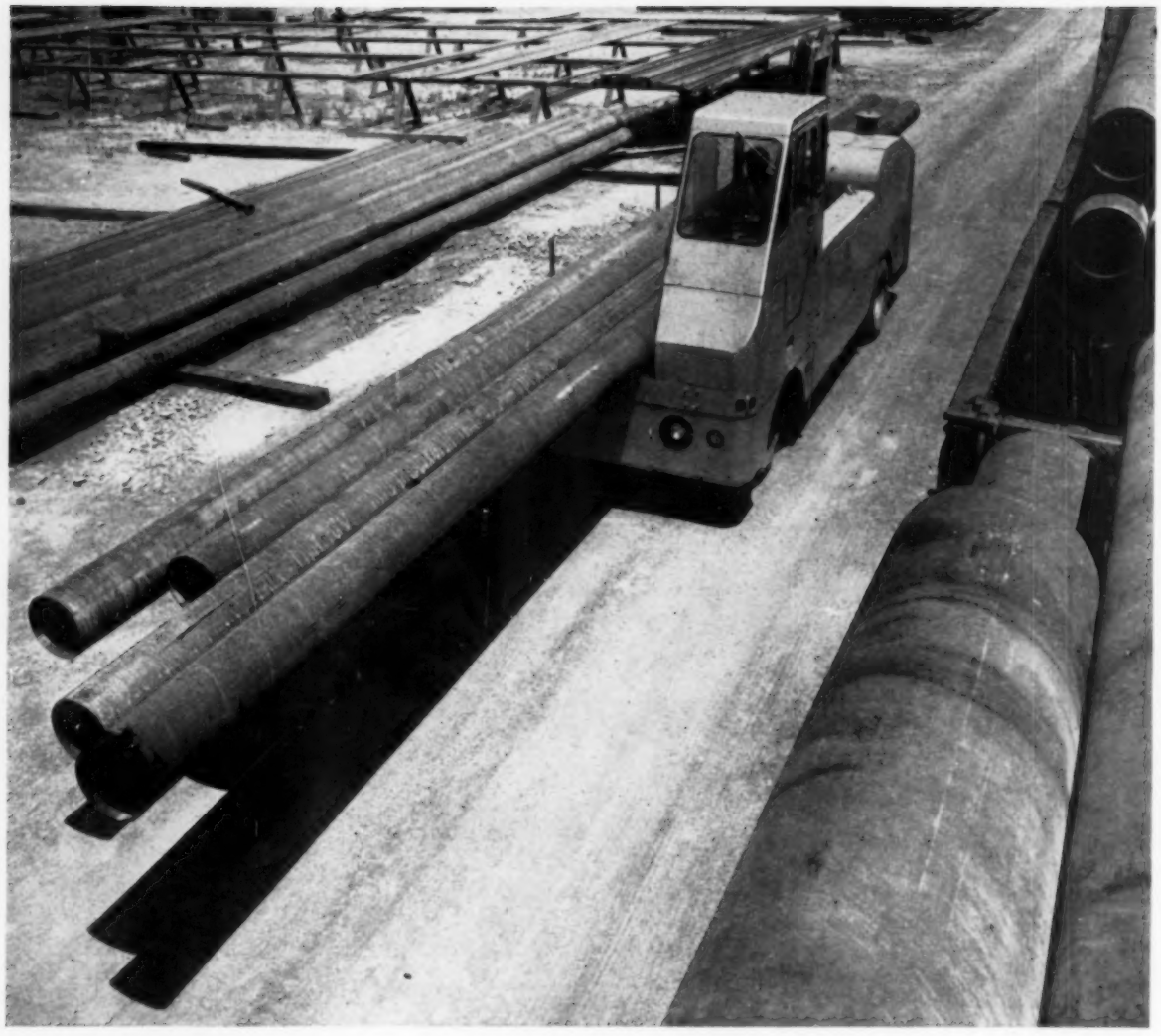
Westinghouse fills the bill by providing the ultimate in circuit simplicity designed specifically for ease of maintenance and interchangeability. Multiplex panels allow up to 30 crystal-controlled channels capable of carrying up to 15 sub-channels for telegraph, teletype, telemetering or supervisory control. Westinghouse system design incorporates automatic alarm and *100% stand-by* for interruption-free service. Above all, Microwave gets through, without wires subject to weather or accident damage.

Get all the details—and the economic advantages—from your nearby Westinghouse sales office—or write to Westinghouse Electric Corp., Carrier-Microwave Department, Box 7425, Halethorpe 27, Md.

J-60908

YOU CAN BE SURE...IF IT'S

Westinghouse



®Traveloader..reduces pipe-handling to an easy one-man job!

BAKER TRAVELOADER picks up loads from the side, carries them lengthwise—safely aboard the truck deck, and stacks them from the side to a height of 12 feet. This makes it the ideal truck for yard handling of pipe or any other long, unwieldy loads. It can operate in 10 ft. aisles, over paved and unpaved roadways—with travel speeds up to 30 MPH.

This one machine with one operator replaces two and often three fork trucks, straddle trucks, portable cranes or straddle carriers—and does the job better. You save manpower, cost of buying and maintaining other expensive equipment, aisle space and time. Unlike a straddle carrier, it also stacks. It requires less aisle space than fork trucks. And it eliminates dangerous dangling and swaying of loads carried by cranes. For complete information, write for Bulletin No. 1360.

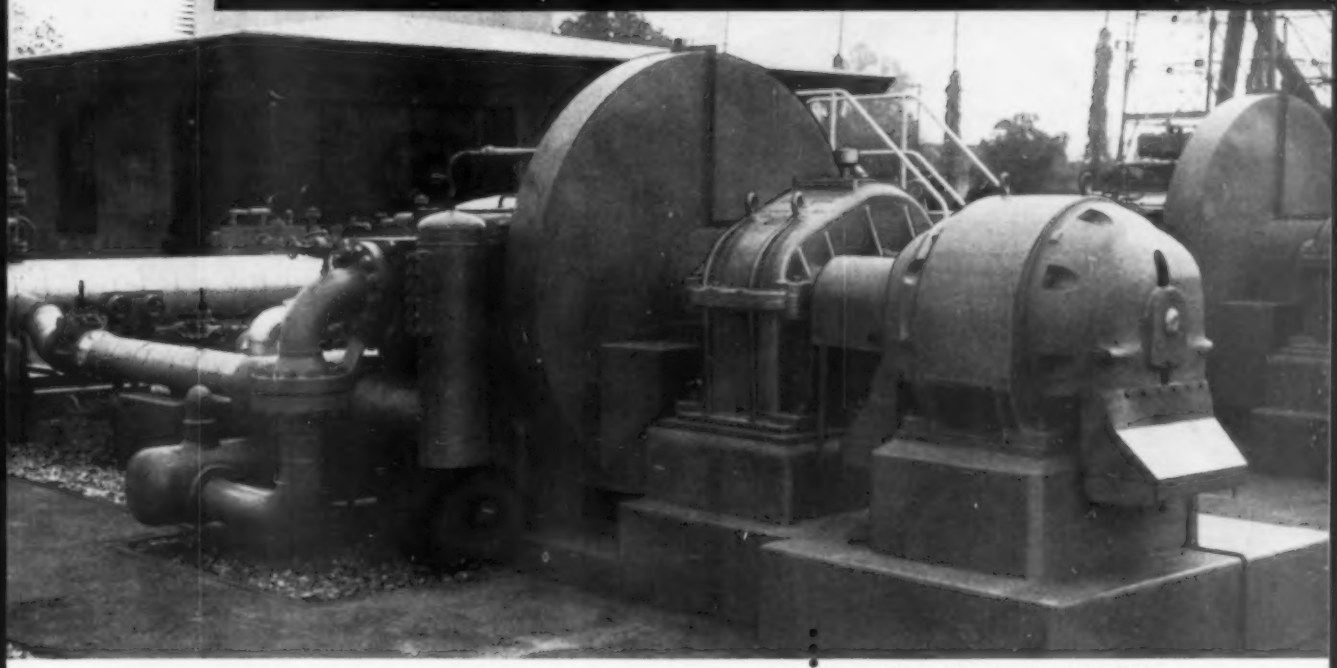
Baker®
industrial trucks

THE BAKER-RAULANG COMPANY
1270 WEST 80th STREET • CLEVELAND 2, OHIO
A Subsidiary of Otis Elevator Company

6T-4

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

12 WESTERN GEAR reducers operate 200°f fuel pipeline



Typical Western Gear installation in one of three Edison pipeline stations

By J. E. BAILEY
Industry Specialist-Petroleum
Western Gear Corporation

Twelve Western Gear speed reduction gears, Model S-63, were wisely selected for the three Edison pipeline stations whose unusual job is to pump 200° F. fuel oil along the 41 mile, eight inch line. Western Gear 6:1 reduction gears driven by 150 HP electric motors, power Cooper-Bessemer reciprocating pumps. The line, engineered and constructed by the Bechtel Corporation to transport fuel to a Southern California Edison Company steam electric generation station, has been operated by General Petroleum since 1952. The Western Gear reducers have been completely trouble-free in operation. This record of Western Gear reliability has been repeated in hundreds of pipeline stations throughout the United States. Complete engineering assistance is available, no obligation. Why not call Western Gear now? Write on company letterhead for new Bulletin No. 5204. Address General Offices, Western Gear, P.O. Box 182, Lynwood, California.

pipeline facts

Fuel oil with a viscosity of 175/185 SSF at 122° F. is heated to 200° and started in the line at the Santa Fe Springs pumping station (see photo) and then directed onwards to the Tonner station and the Euclid station. Each station reheats the oil and the pumping cycle is repeated. The fuel is pumped into storage tanks at the steam station site. The pipeline, designed for 1,000 lbs. maximum pressure, is operated at 650 lbs. pressure at a normal pumping rate of 650-750 barrels per hour. Light oil replaces the heavy fuel oil in the line prior to shutdowns. Elevation of the line varies from 162 to 1200 feet above sea level.

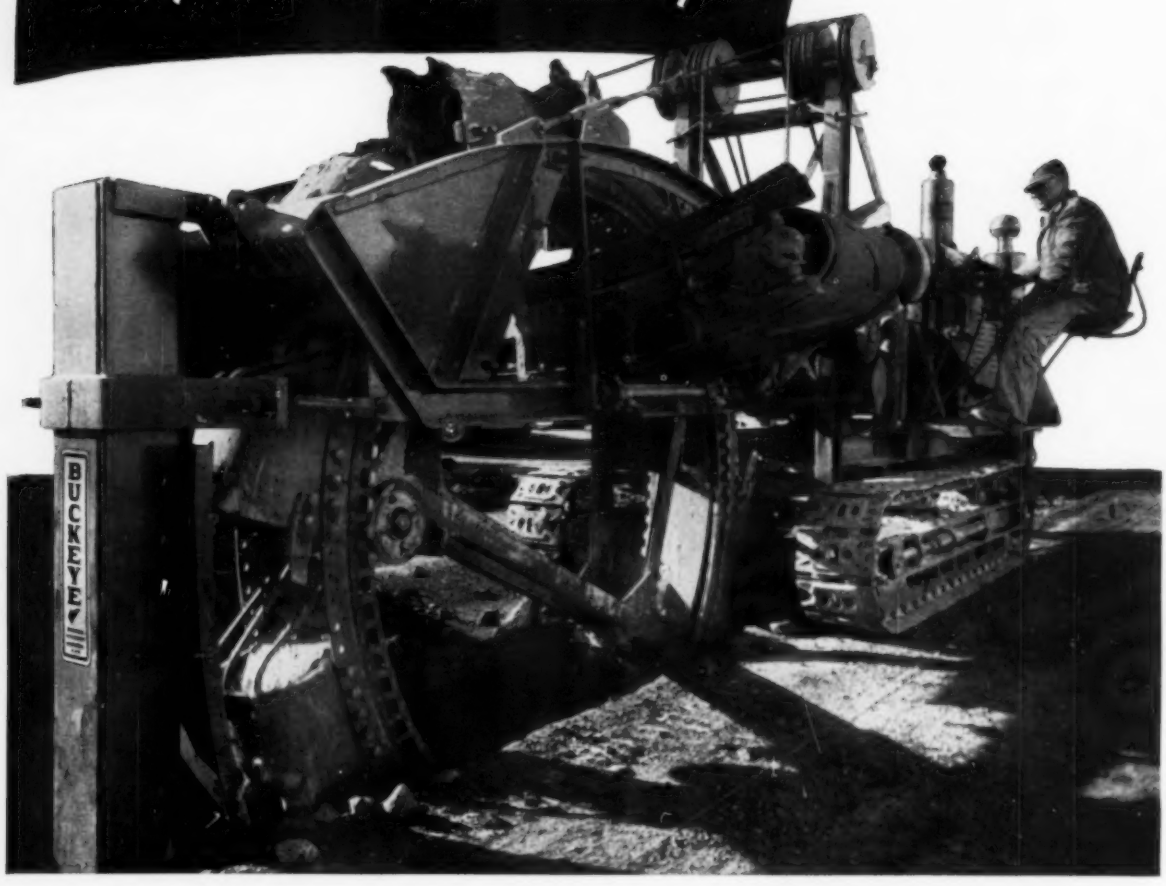
"The difference is reliability" • Since 1888

5640

WESTERN GEAR Corporation
ENGINEERS AND MANUFACTURERS

PLANTS AT LYNWOOD, PASADENA, BELMONT, SAN FRANCISCO (CALIF.)
SEATTLE AND HOUSTON — REPRESENTATIVES IN PRINCIPAL CITIES

60 years in the making...



Buckeye 308, today's most advanced ditcher!

● Advanced features are never achieved overnight. They result from years of experience and engineering know-how . . . months of testing and refinement. Buckeye built the world's first ditcher over 60 years ago. And every major ditcher advancement since has come from Buckeye, including the first ladder- and wheel-type models . . . first pipeline ditcher . . . power by gasoline—then diesel . . . implementation of crawler mounting.

These Buckeye "firsts" pay off big in the 308. Production is greater because advanced design makes more power available at the digging wheel. Operation is faster because grouped controls and live-action hydraulics make adjustments for changing conditions easy . . . without stopping forward travel! Unit life is longer because every part is designed for the job it is to do. And maintenance is speeded up by parts interchangeability and unit construction.

The sum of it all is greater production . . . lower over-all cost . . . far more dependable operation. In every way Buckeye is your *best* buy! Call your Gar Wood-Buckeye dealer soon, or write to: Customer Service Dept., Gar Wood Industries, Inc., Wayne, Michigan.

Gar Wood Buckeye

GAR WOOD INDUSTRIES, INC.

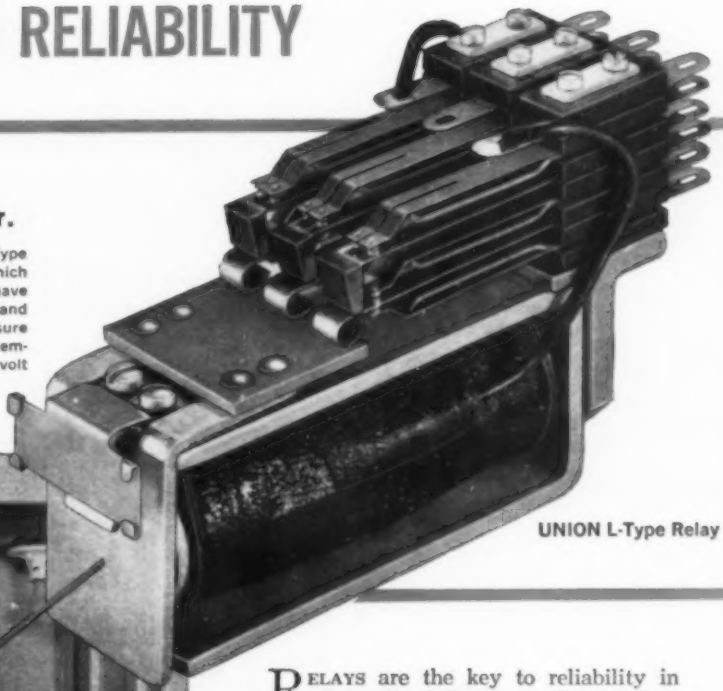
Wayne, Michigan • Findlay, Ohio

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

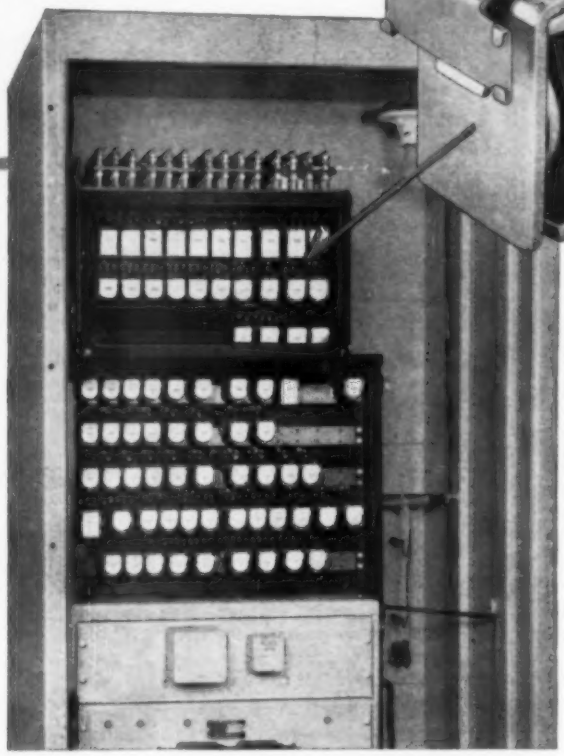
UNION C.T.C. —the pipeline control system with BUILT-IN RELIABILITY

4,000,000 operations a year.

This is regular performance for this L-Type UNION Relay used in the coding unit which transmits and receives all codes. Relays have bifurcated contacts, self-wiping action and chromium plating at the wear points to assure maximum reliability. Coil and contact assemblies are designed to withstand 3000-volt breakdown test.



UNION L-Type Relay



UNION Centralized Transport Control Equipment for the central office (back view) uses plug-connected units for ease of handling.

RELAYS are the key to reliability in Centralized Transport Control Systems—and UNION has been building top-quality relays for more than 75 years.

Here's the proof of outstanding performance: 443 UNION relay coding units, the kind used in railroad and pipeline C.T.C. Systems, were brought into the shop for cleaning and repairs. These had been in service without maintenance from one to 10 years. *For 65% of the units, no repairs were required*—only cleaning and adjustment. 10% required slight repairs on the relay contacts. The remaining 25% had been damaged by lightning. The relays in these units averaged about four million operations a year.

This is an example of the reliability that is built into the components used in a UNION C.T.C. System. It means that you can expect a UNION System to go to work and keep on working with the least possible maintenance cost. Write for a copy of our Bulletin 1052.

Quality First...TO LAST

GENERAL APPARATUS SALES

UNION SWITCH & SIGNAL

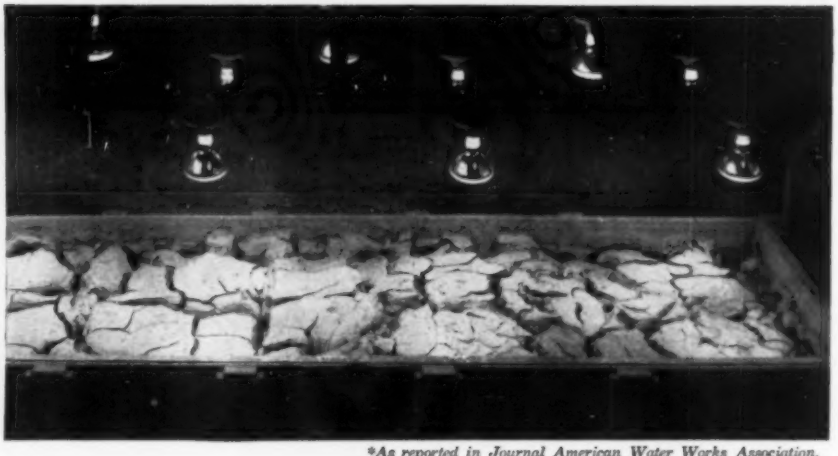
DIVISION OF WESTINGHOUSE AIR BRAKE COMPANY

PITTSBURGH 18, PENNSYLVANIA

What happens to pipe wrap underground?

Here's what a federal agency found out*...

Many wrap and enamel combinations were imbedded in a test tank filled with bentonite clay slurry. Extreme soil stresses were imposed on these samples by alternate wetting and drying cycles. Resistance to backfill puncture was also checked after each cycle. Holiday-detection tests showed that the glass fiber and coal-tar combination stood up through the full 25 cycles of the test.



*As reported in Journal American Water Works Association, Vol. 48, Feb., 1956. Photo courtesy U.S. Bureau Of Reclamation.

These impartial tests show why BLUE FLAG gives you complete pipeline protection

It was conclusively demonstrated that glass fiber mat like Blue Flag, with coal-tar enamel, provides effective protection against *both* soil-stress and backfill-puncture action. (See picture caption above for actual test conditions.)

This is the kind of protection you need for maximum service life. Yet it's yours for only ½ of 1% of initial pipeline cost when you use L·O·F Glass Fibers' Blue Flag.

No wonder glass fiber reinforcement like Blue Flag Pipe Wrap is preferred. It strengthens enamel . . . assures coating essentially free of holidays. And, Blue Flag helps speed application—its high tensile strength virtually eliminates breakage in the wrapping operation.

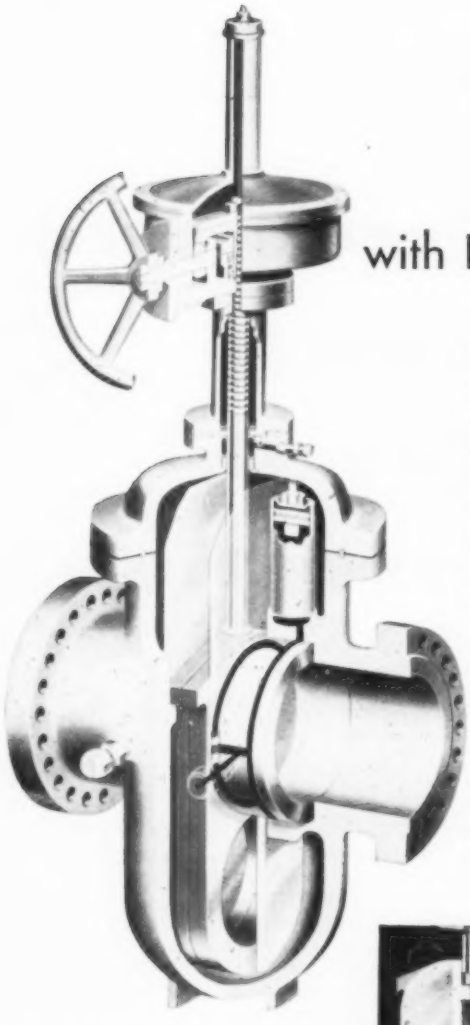
Yard-wrapped, or applied over-the-ditch, Blue Flag can be the answer to your pipeline protection problems. It's available from conveniently located distributor warehouses. For the address of the one nearest you, or for technical information, write: *L·O·F Glass Fibers Company, Dept. 72-37, 1810 Madison Avenue, Toledo 1, Ohio.*

L·O·F GLASS FIBERS

L·O·F GLASS FIBERS COMPANY • TOLEDO 1, OHIO

NEW ADVANTAGES "GO ON THE LINE"

with DARLING-McEVOY Conduit Valves



Compare these features with *any* other pipe line gate valve:

1. EVERY CLOSURE LEAK-PROOF. No forcing. Positive, automatic self-sealing between seats and gate and seats and body by means of sealing compound.

2. NON-DIRECTIONAL. Flow may be in either direction.

3. TWIN SEALANT RESERVOIRS. One for each port. Sealant feeds automatically to downstream side only.

4. NEGLIGIBLE SERVICING. Leak-proof closure requires very little sealant. Reservoir capacity ample for a great many operations.

5. SMOOTH, FULL FLOW. No impediments. No turbulence. No pockets to collect sediment.

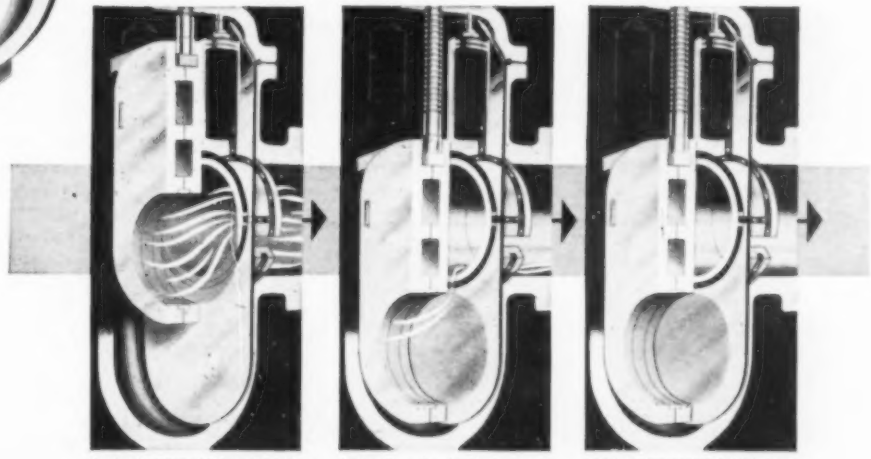
6. REPACKING UNDER PRESSURE. Construction permits replacement of stem packing media with valve wide open under full line pressure.

7. EXCEPTIONAL PERFORMANCE AND LIFE. Self-aligning gates. No wedging. Non-distorting seats, protected when valve is open or closed.

Darling-McEvoy conduit valves, made in 8" and larger sizes, are fully field proved and are now operating continuously on various major lines. For complete information on the self-sealing feature and many other advantages of this unique valve, ask for Bulletin 5402.

Above: *Cutaway showing heavy, self-aligning gate and parallel seat assembly, with one of the two sealing systems indicated.*

Right: *Diagrams of closure action on downstream side of gate.*



APPROACHING CLOSURE... *No loss of sealant as sealing groove in seat is disconnected from reservoir until gate is fully closed.*

CLOSED... *Jumper in gate now permits differential pressure to feed sealant into seat groove to check any remaining flow.*

AUTOMATICALLY SEALED. *Pressures again in balance. Tightness established. No additional sealant used until again needed.*

DARLING VALVES

DARLING VALVE & MANUFACTURING COMPANY

Williamsport 31, Pa.

Manufactured in Canada by Sandilands Valve Manufacturing Co., Ltd., Galt 19, Ontario

Microwave Speeds Ohio Oil Operations

Ralph M. Slough, *Manager Pipeline Communications, The Ohio Oil Company*

EFFICIENT, reliable communications facilities are needed to keep oil moving along a pipeline 24 hours a day. To meet this need, The Ohio Oil Company is currently installing a private microwave communications system to help improve operation over a long system such as Ohio's "big inch" pipeline.

The company's private communications system was first set up in the early 1900's to follow, in general, our pipeline routes. It had been improved and expanded over the years, but about two years ago it was decided that microwave would provide the answer to the ever present maintenance problems of its wire lines and right-of-way.

The new microwave system, purchased from Motorola, Inc., Chicago, extends some 322 miles from the general office building in Findlay, Ohio, to the new Bridgeport Operating Center in Bridgeport, Illinois. It is presently being expanded to include operations in the Wood River and East St. Louis, Illinois, areas. Seventeen microwave stations are now in and operating. Six additional stations will connect East St. Louis and Wood River to the present system at Martinsville, Illinois.

The new system will provide general communication service for Ohio Oil's production, supply and transportation, refining, marketing, and other departments. In pipeline operations, it will permit more centralized control of movements through the company's "big inch" crude oil and refined products lines in Illinois, Indiana, and Ohio. It will provide centralized supervision of the entire pipeline operation through selective telemetering and control.

New microwave system of The Ohio Oil Company provides communications from the general offices in Findlay, Ohio, to the new Operating Center in Bridgeport, Illinois.

Microwave Facilities

Ohio Oil's microwave equipment operates in the 6000-mc band. Antennas are mounted on the roofs of the microwave buildings and are either 40-in. or 6-ft diameter parabolic reflectors fed by a waveguide horn. Keeping the microwave "dishes" at ground level eliminates long waveguide runs, and simplifies maintenance.

These antennas provide high radiated energy concentration with beam widths of 3 deg for 40-in. paraboloids

P 615.36

Voice, control, supervisory channels plus selective telemetering system increase efficiency of Ohio Oil Company's cross-country pipeline operations

Microwave tower at Ohio Oil Company's main office in Findlay, Ohio, (top left) is built on the highest portion of the Donnell Building 124 ft above street level. The tower itself is an additional 80 ft high. Microwave tower at the Lima, Ohio station (right) of the Ohio Oil Company "big inch" pipeline.

and 1.7 deg for 6-ft paraboloids. The particular antenna used in any particular situation depends upon the height of the passive reflector on the tower and the microwave path length. Energy from the antenna is directed vertically to a solid aluminum passive reflector mounted atop an adjacent tower. The reflector directs the concentrated energy horizontally to the next microwave station.

The microwave transmitter is a single reflex klystron, directly frequency-modulated. The power output is 100 milliwatts that, coupled with the high antenna gain possible at these frequencies, provides a signal strong enough to reliably span even our longest "hop" of 34.6 miles. All multiplexing signals are combined in a modulation amplifier that feeds the transmitter klystron. The receiver local oscillator employs a similar reflex klystron whose output is mixed in a crystal with the incoming signal. The mixer crystal feeds a high gain IF amplifier at the 75-mc difference frequency. The IF strip output is the recovered baseband of the microwave carrier.

Initially, 21 voice channels are utilized to provide 29 independent telephone circuits. In addition, one voice channel is used in a party line type circuit for telemetering, teletypewriter, and supervisory control signals, and a second for control of VHF base stations that operate as part of the mobile two-way radio system.

For telephone communication, 24 circuits are utilized for duplex private line operation and 5 circuits for simplex party line operation. The party line circuits are equipped with selective dialing so that only the desired station is signaled. Two additional subcarrier channels are used: One for a simplex control of VHF base stations, and one as a line for audio tones.

The buildings, towers, and passive reflectors were erected by Andrew Tower, Inc., of Fort Worth, Texas. Tower heights range from 65 ft at Terre Haute, Indiana, to 320 ft at Roachdale, Indiana. Tower height depends on the elevation necessary to obtain line-of-sight clearance for the radio paths between stations. The buildings are of cast concrete construction.

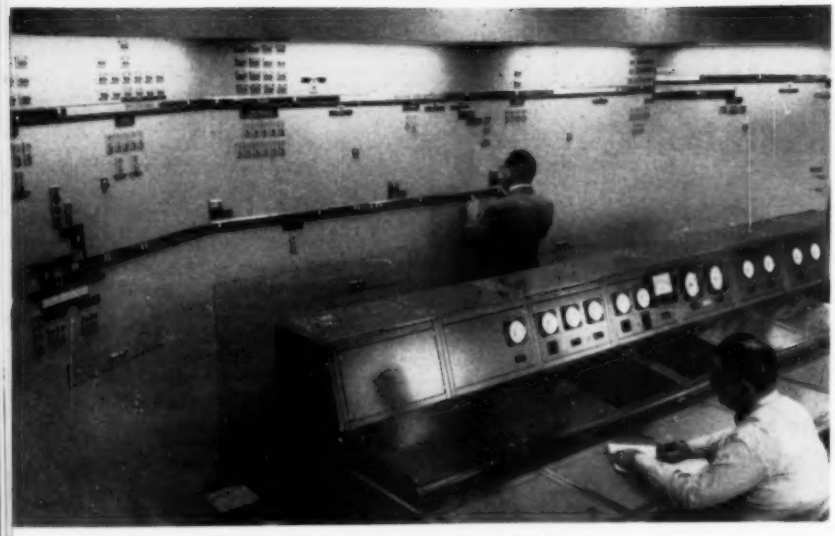
Audio Tones Key Telemetering

Teletypewriter, telemeter selection, and telemetering circuits all employ frequency shift voice frequency carrier equipment. VF carrier provides 18 separate audio tone carriers between 500 and 3100 cps for transmission over an audio channel. Each VF carrier transmitter can be shifted in frequency to either a mark, neutral or space frequency. The mark frequency is 30 cycles below the channel frequency, the neutral is the channel frequency, and the space is 30 cycles above the channel. Teletypewriter and telemetering circuits utilize the mark-space shift for transmission of telegraph signals. The telemetering selection circuits utilize the neutral and the mark-space frequencies.

Findlay Control Point

The main office of Ohio Oil in Findlay, Ohio, is the nerve center for Ohio's entire "big inch" pipeline system. Selective telemetering and supervisory control of automatic pumping operations are all read and controlled from this point.

The master control console at Findlay is divided into two independent sections, "product" and "crude," denoting the two pipelines being monitored. It is equipped to give indications of pressure, both suction and discharge, and specific gravity of line content from a desired station on a selective basis. At the same time, any tank at that station may be selected and checked for fluid level.



Master control console at Findlay is divided into two sections, "product" and "crude," denoting the two pipelines being monitored.

Five types of telemetered readings are returned from various stations throughout the system:

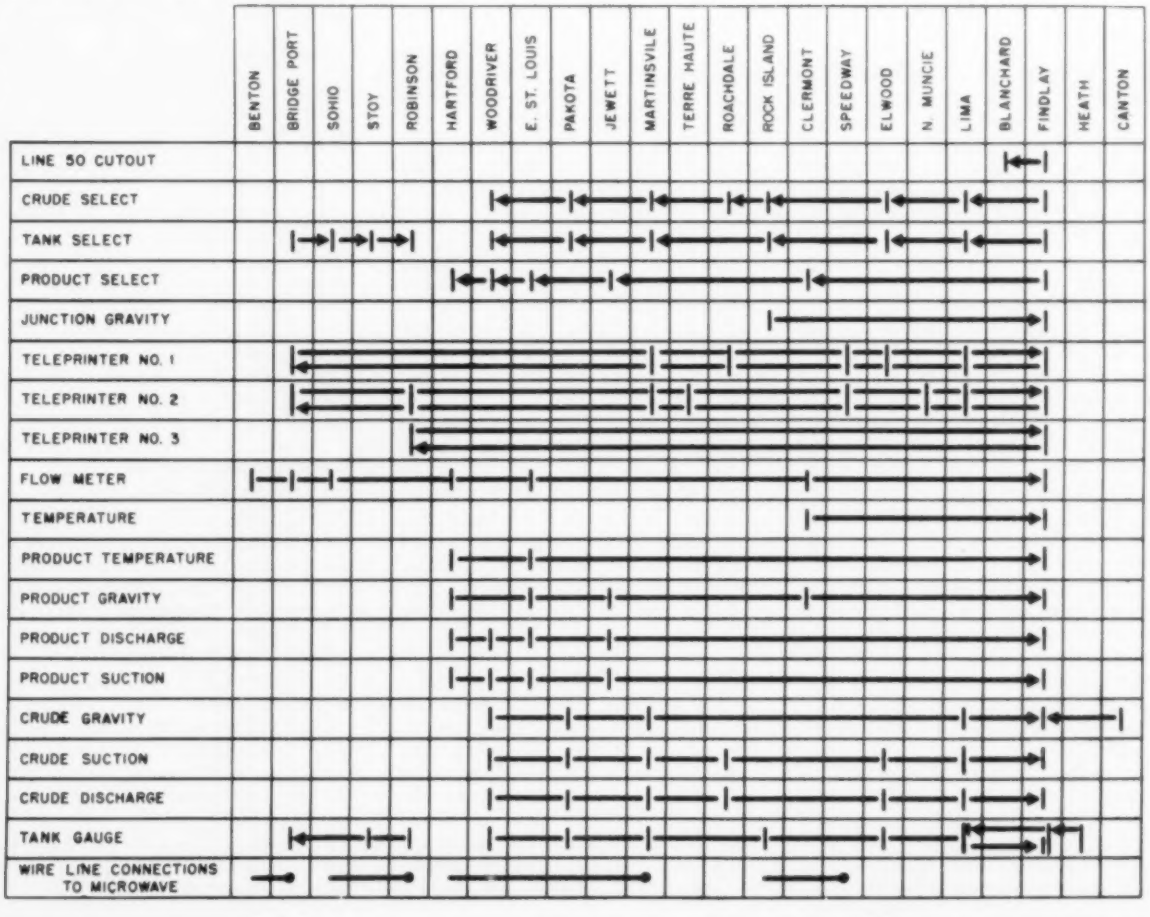
1. Tank level gaging
2. Pressure readings, both suction and discharge
3. Specific gravity of pipeline contents
4. Positive displacement flow meter readings
5. Line temperature readings

A "batch board" is situated directly behind and above the console. Here, information gathered at the console is transferred manually to the appropriate section of the board. Colored plastic chips denoting batches, etc., are moved along the board providing the console operator with an overall operational picture at all times.

Console Operation

The process of metering any value on the system involves, first of all, selecting the station. This is done by pressing the selection button for the desired station. Individual lights indicate when the station is tied into the console via the microwave system.

Selective telemetering function chart illustrates stations at which given quantities are metered or selected throughout the system from the Findlay control console.



Engineer checks microwave RF equipment at Martinsville, Illinois, pumping station. Waveguide goes up through the ceiling to parabolic antennas mounted on building roof.

Engineer reads annunciator panel connected to automatic control equipment and pump controllers at Elwood, Indiana, pumping station.

Suction and discharge pressures, specific gravity, and temperature of the pipeline contents are continuously indicated on four console meters as long as that particular station remains selected. When it is desired to check the level in one of the storage tanks at the station, an associated tank button for that specific tank is depressed. The level transmitter on the tank then sends the level signal to two meters on the console. One meter indicates the level in feet, the other in inches to the nearest ⅛-in. over the foot mark.

Flow Readings

Flow meters at certain pumping stations continuously measure the flow through the station. A Metrotype machine working with the flow meter converts information into teleprinter code. When queried by Findlay, this code is transmitted over a teleprinter loop. As the teleprinter loop includes several stations, flow information is printed at all stations on the loop. The code information also includes the identification number of the station being checked. Flowmeter readings are transmitted only when a station is selected by the Findlay operator.

Automatic Pumping and Supervisory Control

At the Elwood and Roachdale, Indiana, crude oil pumping stations, equipment is installed that will automatically control valves and pumps in response to line demands. Elwood station has four pumps, one 2500-hp, one 1500-hp, and two 600-hp boosters, all electrically driven. Operating condition of this station is shown continuously on the Findlay console. Dispatchers there are able to control the Elwood pumps if desired. Automatic operation, and remote monitoring and control, eliminates the need for complete, around-the-clock attendance at the station. Roachdale station, with two 2500-hp units, is operated in the same manner as Elwood.

Lockout features are included in the automatic and remote control of the Elwood and Roachdale stations. Any one of the individual pumps may be locked out, either locally at the station or at Findlay. If a pump is locked out at either Elwood or Findlay, it cannot be started from the other point until the lockout is removed. An "automatic-manual" operation selector at Elwood must be in the "automatic"

An Ohio Oil Company storage tank with automatic level indicating equipment. Readings can be selected for any tank along the "big inch" pipeline and be transmitted over the microwave system to the dispatcher's console at Findlay, Ohio.

Engineer at power panel of electric motors driving pumps at Patoka, Illinois, pumping station. As different batches pass through, information is relayed via microwave to offices in Findlay, Ohio, where a "batch board" record is kept to give an overall picture of pipeline operations.

The Author

Ralph M. Slough, manager of pipeline communications for The Ohio Oil Company, is a veteran of 34 years in the oil business — all with Ohio Oil. A native of Defiance County, Ohio, he attended Findlay High School and studied electrical and radio engineering with the National Radio Institute, Washington.

His pipeline work began in 1927 when he worked on the electrification of the lines between Lima and Negley, Ohio, and Yates and Lytle, Texas. He was placed in charge of electrical installations at the General Office Building in Findlay in 1929. The next year he also headed electrical work for production and marketing in the Findlay area.

When Ohio Oil built its Sales and Engineering Building in 1935, Slough was in charge of construction. In 1938, he was appointed superintendent of communications. In 1941 he was named superintendent of building construction and pipeline booster station construction. He has since held similar positions in the Findlay general office.

He is a registered professional engineer in Ohio.

VHF radio base station mounted in a weatherproof housing at the microwave tower at Ohio Oil Company's Martinsville, Illinois, pumping station. The VHF antenna is mounted on the top of this tower.

position for the Findlay operator to start the pumps. The console at Findlay is equipped to stop or lock any of the pumps regardless of the position of the selector switch.

VHF Radio System

VHF radio base stations are located at various microwave repeater stations to supply blanket coverage of the entire system for our mobile radio-equipped vehicles. The mobile radio system includes units in maintenance trucks and stationwagons, as well as other vehicles. The mobile radio system enhances the overall efficiency of all pipeline operations and aids in rapid communications with key maintenance and management personnel who may be out along the pipeline system.

Control points at the Findlay and Lima stations can operate base stations at Lima, Ohio; New Mt. Pleasant, Elwood, and Jamestown, Indiana, over one microwave subcarrier channel. A control point at Martinsville, Illinois, can operate base stations at Catlin and Jamestown, Indiana, and is to be expanded to include control of stations at Altamont and Grant Fork, Illinois, each with a separate voice channel.

The four base stations controlled by Findlay or Lima can be operated singly or collectively by either dispatcher. Three of four base stations are locked out when a mobile signal is received at any station. This arrangement prevents simultaneous transmission of two signals from the VHF receivers down the same microwave channel to the control point.

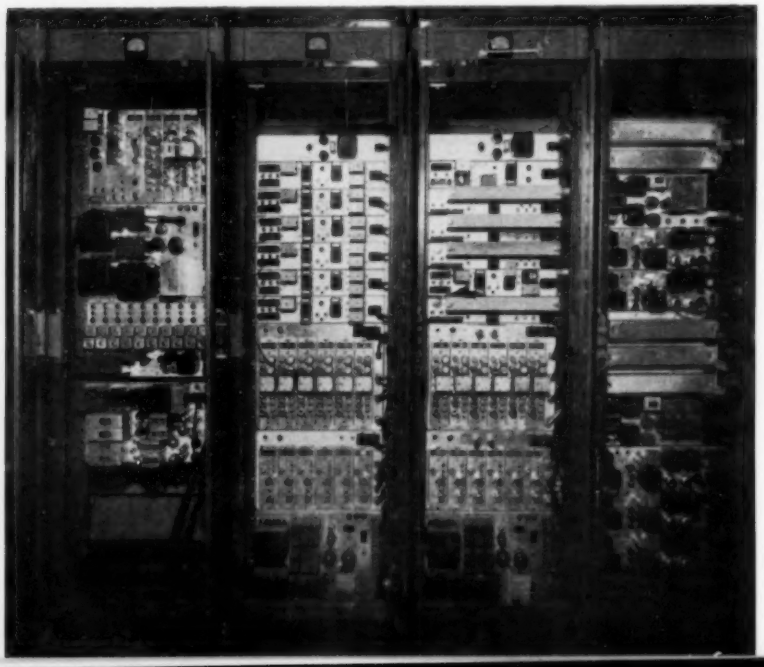
The microwave equipment incorporates an automatic alarm system that provides a coded signal to Findlay on the east end, or to Martinsville on the west end of the system. The automatic alarm alerts either station in the event of a top tower light failure, primary power failure, or a switchover to standby RF equipment. The coded sequence indicates the type of outage and at what station it occurs. Some thought has been given to alarming repeater station doors so that illegal entries can be detected.

It is too early to give any concrete figures with regard to cost advantages of the microwave system, but Ohio expects that the results will more than justify our original analysis. Many of the benefits are intangibles that add up to more efficient operation.

Microwave has proved to be more reliable under all weather conditions — one of the reasons that we installed it. So far, our experience has shown that commercial power interruptions have been the source of most of our communications continuity problems, although these problems have been minor through the use of standby power generators.

Much of the data required by the Findlay office was collected previously by individual telephone reports. Now, instead of waiting for hourly reports or calling for specific information on pipeline conditions, it is only necessary to press a button on the console. This type of operation eliminates much of the time-consuming data gathering formerly required of field men, and automatically gives better overall efficiency to both company and customer service functions. ★ ★ ★

FM multiplex and termination equipment at the Martinsville, Illinois, pumping station.



Texas Gas' Microwave System . . .

Designed To Grow

Dependable communications from Owensboro headquarters to Lake Charles division offices, with 20 intermediate points, provided by multi-circuit, expandable system

Haddon S. Wilson,
Systems Project Engineer
Communications Products Department,
Radio Corporation of America

SPANNING a five-state area and linking 22 compressor stations and field offices is a new 700-mile microwave system, designed to meet present and future communications requirements of Texas Gas Transmission Corporation.

Stretching across the states of Kentucky, Tennessee, Mississippi, Arkansas, and Louisiana, the system includes 32 stations that provide 33 voice channels and an ultimate capacity of 60 channels to meet operational requirements.

Operating in the 2000-mc band, the new system utilizes crystal controlled voice channel multiplex equipment.

Facilities provided initially are as follows:

1. **Service and fault channel.**
2. **One dispatch party line channel.**
3. **One operational party line channel.**
4. **One VHF control channel.**
5. **Three switchboard to switchboard trunk channels.**
6. **Two direct line telephone channels.**
7. **Twenty-five operational private line channels.**

Wideband Assemblies Used

Microwave radio equipment being utilized in the system is wideband radio terminal and repeater assemblies equipped with standby facilities. (See Fig. 1.) Heterodyne repeaters on the basic system are employed operating with a frequency shift of 40 mc (either up or down). Only two RF channels are required under normal conditions with the transmitting frequencies alternating at successive stations.

This method of relaying improves frequency control and permits easier level setting through elimination of successive demodulation and remodulation. The RF carrier is frequency modulated and overall frequency response is flat within 0.5 db, relative to the 5 kc response from 3 kc to 500 kc.

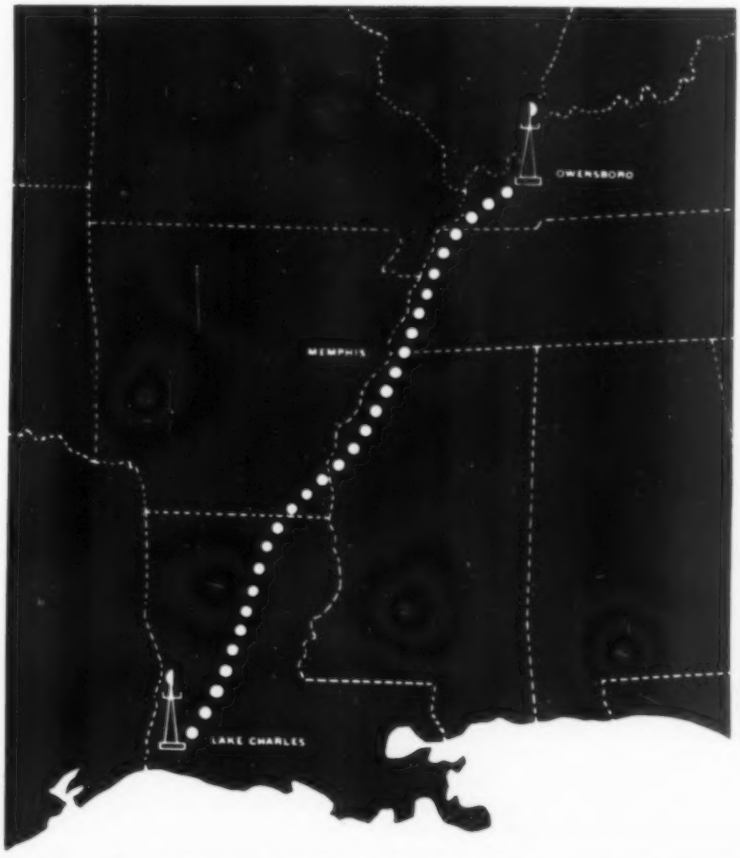
Because of this heterodyne principal, a high degree of gain stability for all intelligence on the carrier is obtained regardless of the number of repeaters in the system. At no intervening repeater, whether it be a through repeater or drop repeater, does through traffic become demodulated before being retransmitted. Therefore, baseband information preserves a constant deviation throughout the system as initiated at the originating source.

Installation and maintenance is also simplified by use of the heterodyne principal. This means that:

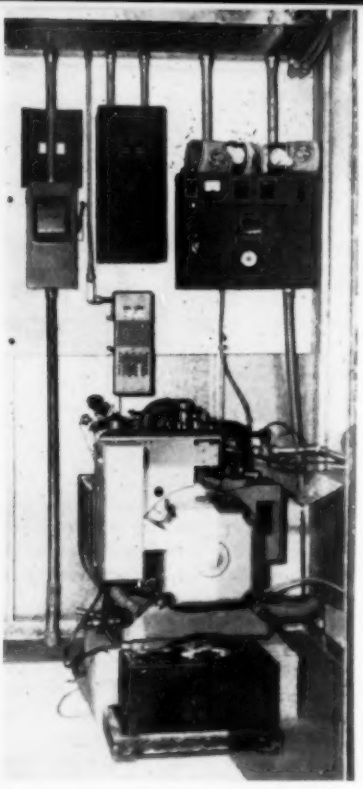
- Equipment is designed so that each station can be lined up independently.
- Levels are set only between the terminal points where particular channels appear.

Thus, no trips to intermediate repeaters are required as far as setting levels are concerned, because all information is heterodyned at the repeater and levels are preserved in terms of frequency deviation of the carrier.

Lighthouse triodes used in the 2000-



Route of Texas Gas Transmission Corporation's new 700-mile microwave system is traced on map by white dots, representing the 30 intermediate stations between Owensboro, Kentucky, headquarters and the Lake Charles, Louisiana, division offices.



Standby power unit at Cardova, Tennessee, repeater station is engine generated. At some compressor station locations, station emergency power is used.

nic systems in the conversion and carrier multiplier circuits are not voltage sensitive or subject to critical timing circuits. Non-regulated power supplies, which are highly dependable and easy to maintain and only require external regulators on poor primary circuits, are used.

In anticipation of eventual frequency spectrum crowding, equipment is designed for economical use of spectrum. By using a basic 2-frequency system and a 6-mc intermediate frequency bandwidth, this equipment uses minimum frequency spectrum for a given number of voice circuits.

Conservation of the frequency spectrum is an added assurance against obsolescence. Only two frequencies are required and single sideband frequency division multiplexing is utilized.

Service Channel at Each Station

A service channel unit — an integral part of radio relay equipment — is included at each station. This channel provides a talking circuit for use of maintenance personnel and a signaling circuit for station code ringing.

It also includes selective circuits that will respond to incoming fault signals, ring a buzzer in synchronism with them, and pass them on to the associated fault unit. Service channel unit is used in conjunction with either the fault transmitter (coder) or fault indicator (decoder). When used with the fault transmitter, it generates fault signals in response to coded pulses from the transmitter.

In the fault transmitter is a circuit that locks out all fault transmission for 30 seconds after the reception of the first train of fault tones from any other fault transmitter in the system, insuring non-overlap of fault signals.

At fault reporting points, the code is visually presented on an annunciator panel. These panels are installed at Owensboro, Kentucky; Memphis, Tennessee; Guthrie and Eunice, Louisiana. The annunciator panel indicates the station "in fault" and the nature of the difficulty.

Alarm system will indentify the following conditions:

A. Operation of standby generator.
B. Failure of standby generator to start or to operate full duration of power failure.
C. Switchover to standby microwave equipment.
D. Failure of tower top light or flashing beacon.
E. Failure of tower side light.
F. Transfer of RF power supply.
G. A spare alarm circuit.

Fault indication is continuous until the initiating facilities are repaired. Reception of more than one alarm may be received in sequence.

Channelizing the System

Multiplex equipment is of the single sideband, suppressed carrier type. Signaling is out of band with the signal oscillator frequency, 3500 cycles removed from the modulator frequency. All channel and translator frequencies are stabilized by crystal controlled oscillators.

The channel plan consists of 10 basic channel terminals using carrier frequencies spaced at 4-kc intervals, utilizing the lower sideband in each case. These fundamental channels occupy the frequency spectrum from 4 to 44 kc to provide channels 1 to 10.

Second and third groups of 10 channels are shifted in the frequency spectrum by using the lower and upper sidebands of 96-kc translators. Thus, 30 channels occupy the range of 4 to 140 kc. A second group of 30 channels may be operated through a translator to position these channels in the frequency spectrum 152 to 288 kc.

Dispatching Party Line

All dispatching points are connected on a party line basis in accordance with system requirements. This service will be completely 4-wire party line. Access to channels is gained by merely raising a 4-wire dispatch party line handset. Signaling is by code ringing.

Operational Party Line

An operational party line is dropped at 18 locations on a 4-wire basis. These channels are interconnected at each drop to a 100-station dial selector panel. A 2-wire dial telephone is connected to the 2-wire drop from the selector. During idle periods at any channel location, the channel acts as a 4-wire termination with a hybrid in the 100-station selector disconnected.

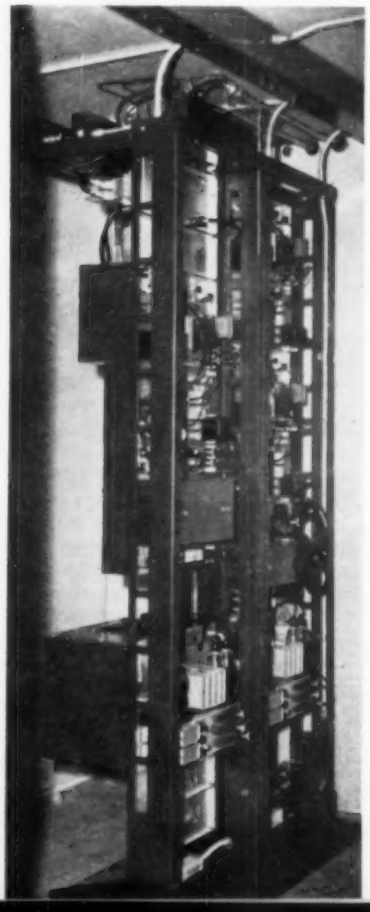
At Owensboro, Holmes Road, and Lake Charles the 2-wire drop from the selectors are connected to line circuits on switchboards. This circuit provides private line dialing from one station to any other station or group of stations. Party line "listening" is provided at all locations as an optional feature.

Operational Private Line Service

Each drop point on the system is provided with private line dial service, which will give complete privacy between any two points. At each drop location, other than Owensboro and Guthrie, adapters are connected to the channel unit to permit interconnection to a dial handset or a manual switchboard. Ring-trip plus supervision is included.

At Guthrie, 19 multiplex channels terminate on an automatic switchboard.

RF and multiplex equipment racks in Covington, Kentucky, station.



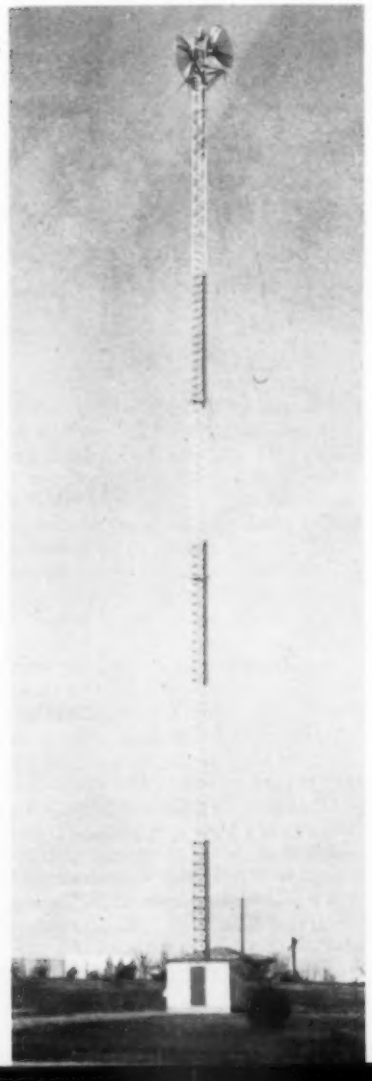
In addition to the multiplex channels, local telephones are connected to other line circuits on the board. The switchboard is equipped with 50 lines and three 2-way dial trunks.

A trunk alternating feature is provided. The three trunks are connected via microwave to a switchboard at Owensboro supplied by Texas Gas Transmission Corporation. At this board six multiplex channels terminate on line circuits. Thus, it is possible for any private line circuit on the system to reach any other telephone either through its own board at Owensboro or Guthrie or via a trunk circuit through both boards.

Direct Private Line Circuit

Certain traffic must have direct access to the microwave between two telephones. This occurs on two circuits. One is between Owensboro and Lake Charles, and the other is between Owensboro and Guthrie. These circuits are provided with adapters connected to the multiplex at each drop, which will operate from a 2-wire telephone or a manual switchboard. Upon raising the handset off the hook-switch or by circuit closure at the manual switchboard, the opposite end of the circuit will be provided with a-c ringdown until answered.

Repeater station and tower at Covington, Kentucky, is adjacent to compressor station.



VHF Control Channel

Included at 14 locations, on a party line basis, is a VHF control channel. There are three control points on this system — Owensboro, Holmes Road, and Guthrie.

VHF control selectors capable of handling up to 100 party line stations are connected at each drop to the channel signaling circuit. A control station may dial any controlled station or another control station. Upon receiving the correct impulses, the VHF audio receive line at the chosen station is connected through the selector to the multiplex channel. A push-to-talk circuit is also completed through the selector.

When the control station initiates transmit keying only the chosen station will respond and the VHF transmitter at this station will be keyed. A separate tone channel directly on the baseband is used for push-to-talk control. When the dial seizure tone is turned off at the control point all selectors will return to normal and re-set in preparation for the next call.

During idle periods on the VHF control channel any base VHF receiver may receive selective calls from mobiles and the audio will be transmitted via microwave to the three control locations. Intercom is also provided between the three control locations.

Each VHF selector is provided with a one minute timer to protect against continuous VHF transmission.

The dialing control unit at the three control locations is a desk mounted box equipped with a dial, a keyswitch, and a "circuit on" light. A control unit with a microphone is also a part of this installation.

Junction Station

A three-way junction station is supplied at Lake Cormorant. This junction is arranged so that a radio terminal terminates the Lake Charles to Lake Cormorant circuit, while a drop repeater connects the Owensboro-Lake Cormorant circuit to Holmes Road in Memphis.

Interconnection between the terminal and drop repeater is provided through a baseband bridging amplifier that also permits local channel dropping.

Future Additions

Due to the importance of possible future telemetering and supervisory control, adequate consideration has been given to handling the expected heavy traffic.

Microwave equipment being provided will handle any type of standard impulse or frequency type telemeter. A telemetered quantity can be transmitted via microwave either as continuous information, or on demand. Method used depends upon the importance of receiving continuous readings as compared to the availability of frequency spectrum and cost of carrier facilities. Either method may be used on this system in the future.

Supervisory control, teletype, facsimile, and telemetering may be added to the system as future needs dictate.

System Details

Longest microwave link in the system is about 35 miles. Path designs call for a received signal fade margin of 30 db, or better. This means that the signal could decrease to as little as 1/1000 of normal value and still be audible over this noise level.

Tower heights on the system will average 200 ft with the tallest being 300 ft. Standby power for unattended stations will be by engine generator units. Many stations will be at compressor stations and will use station emergency power. Those stations to be constructed at unattended locations will be of sheet metal, with plaster board ceiling and walls, and fiber glass insulation. All stations are provided with RF standby equipment.

Installation

This system is a "turn-key" installation with RCA providing all buildings, towers, standby power plants, fences as required, and the installation and test of all electronic equipment. ★ ★

The Author

H. S. Wilson, systems project engineer, Communications Products Dept., Radio Corporation of America, graduated from Queen's University, Kingston, Canada with a BS degree in electrical engineering. In 1950 he attended the Canadian General Electric Company Test Course and in January 1951 transferred to that company's microwave systems engineering group as a systems engineer. Since joining RCA in 1953, Wilson has been engaged in multichannel VHF and UHF relay systems design. He is an associate member of the IRE and a registered professional engineer in Ontario (Canada).

RESULTS OF BUREAU OF STANDARDS' **Part 2**

45-Year Corrosion Study

Melvin Romanoff, *Chemist Corrosion Section, Metallurgy Division, National Bureau of Standards*

Controlling Influence of Soil

Evidence of the controlling influence of the soil on the character of corrosion is further exemplified in Figs. 6 and 7 by the striking similarity in the pattern of corrosion for the different commonly used ferrous metals, as well as for the different low-alloy steels, which were buried in the same soil environments. Although all plain ferrous materials in a given soil environment showed similar corrosion patterns, the type of corrosion varied widely in different soils. Photographs of plain carbon steel, which had been exposed to widely different soil conditions for 14 years, are shown in Fig. 8.

Included in the field tests were low-alloy cast-irons containing up to 3 per cent of nickel with and without copper. Results obtained on these low-alloy cast-irons after exposures up to 14 years showed that the presence of nickel or copper had no significant effect on the corrosion of cast-iron in any of the soils. Specimens of an austenitic cast-iron, containing about 15 per cent nickel, 2.5 per cent chromium, and 6.5 per cent copper were considerably more resistant to corrosion than plain cast-iron.

Data have been obtained on low-alloy steels representing the following materials: Copper-bearing steel, copper-molybdenum open-hearth iron, copper-nickel steel, 2-per cent nickel-1-per cent copper steel, and steels containing from 1 to 6 per cent chromium with and without molybdenum.

The general effect of the alloying elements in these steels was to reduce the initial rate of weight loss, but to increase the initial rate of pitting, as compared with plain carbon steel. Except in the very poorly aerated and reducing group of soils, however, the rate of pitting diminished with time more rapidly for the alloy steels than for plain steels. As a result the maximum depths of pits after 14 years of exposure were less on the alloy steels than on the plain steels. Chromium was observed to have the most pronounced effect in reducing weight loss, but for maximum reduction in pitting, molybdenum also was necessary. Chromium and molybdenum were particularly effective in reducing the corrosion of alloy steels exposed to the most corrosive site, a cinder fill.

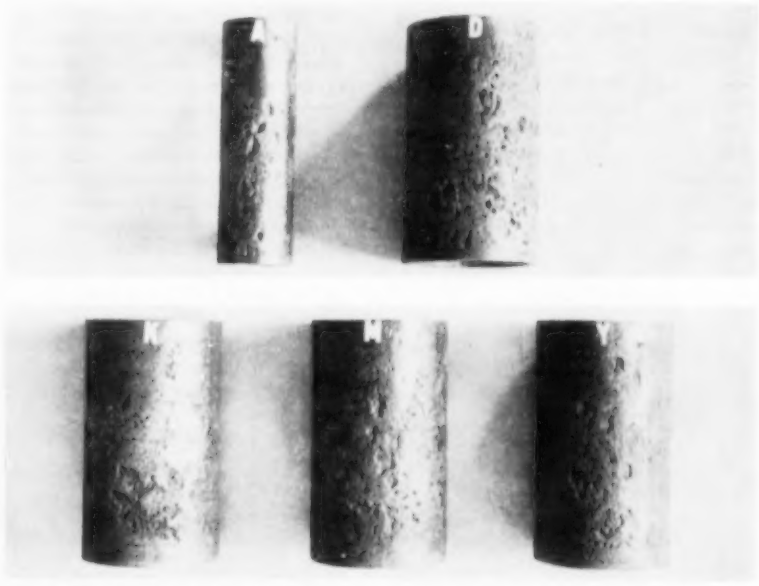


FIG. 6. **Different wrought materials** exposed to Hempstead silt loam for approximately 12 years. Note similarity of corrosion patterns of the different metals.

A, open-hearth iron; D, wrought iron; K, open-hearth steel; M, Bessemer steel; Y, open-hearth steel with 0.2 percent copper.

Also included in the field tests were higher alloy steels containing up to 18 per cent chromium, with and without the additions of nickel and molybdenum. Increasing the chromium content of steels caused a gradual decrease in weight loss, but pitting was accelerated by additions of chromium beyond 6 per cent. In fact, steels of types 410 and 430, which contain about 12 and 17 per cent of chromium, respectively, were observed to have deeper pits than plain steel in most of the soils. The tendency of high concentrations of chromium to accelerate pitting appears to be neutralized by adding sufficient nickel to produce steels of the austenitic type, such as steels 302 (18% Cr, 9% Ni) and 309 (22% Cr, 13% Ni), which were found to be almost wholly resistant to corrosion (Fig. 9). ASI type 316 steel, which also contains molybdenum, in addition to 18 per cent chromium and 11 per cent nickel, showed negligible weight loss and no pitting in all of the 15 corrosive soils to which it was exposed for 14 years.

Results obtained on pipe specimens of copper and copper alloys exposed up to 14 years in a wide variety of soils indicate that tough-pitch copper, deoxidized copper, copper containing up to 3 per cent of silicon with and without additions of tin, and red brass, which consists of 15 per cent zinc, all behave essentially alike. The environments found to be the most corrosive toward these alloys were soils, including cinders, that have high concentrations of

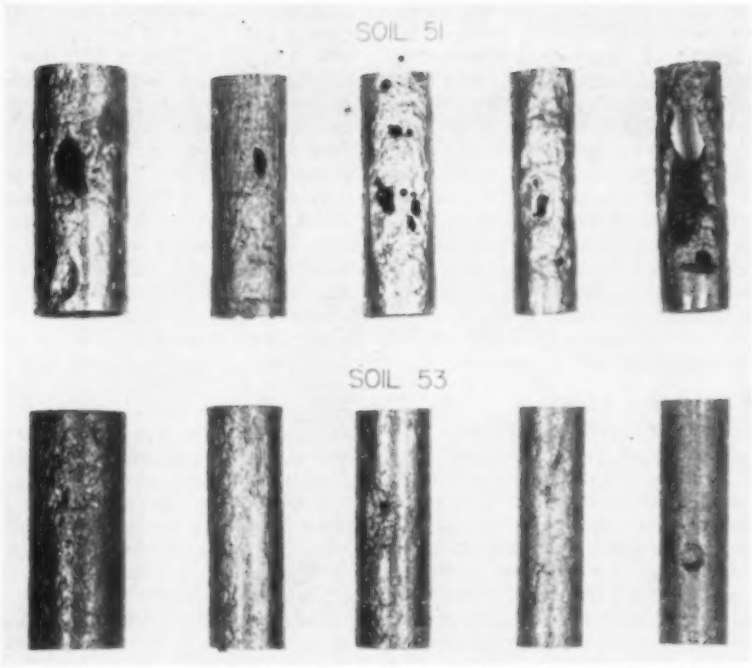


FIG. 7. **Sections of specimens** exposed to very corrosive Acadia clay (soil 51) at Spindletop, Texas, and moderately corrosive Cecil clay loam (soil 53) at Atlanta, Georgia, for 14 years.

Note the similarity of corrosion patterns of the different metals in the same soil.

N, plain carbon steel
A, wrought-iron
H, copper-molybdenum open-hearth iron
D, 2 percent nickel, 1 percent copper steel
G, plain cast-iron

sulfides, chlorides, or hydrogen-ions.

The corrosion rate of copper-zinc alloys, which contain more than 27 percent zinc, increased approximately with the order of increasing zinc content and was accompanied by dezincification, except in those soils containing moderate or high concentrations of sulfide. In the sulfide soils the corrosion rate of the brasses decreased with increased zinc content and the specimens were immune to attack by dezincification. Specimens of a 60-40 brass, which contained 0.08 per cent arsenic, were not subject to dezincification in any of the same soils, but the presence of arsenic induced serious intergranular corrosion in the specimens exposed to cinders.

Zinc is not used as a material of construction underground, but it is used extensively in the protection of ferrous metals, either as a coating or an expendible anode for cathodic protection. The poorly aerated soils, as a class, are corrosive to zinc, as are soils of good aeration containing high concentrations of chlorides and sulfates, acidity, or alkalinity.

Chemical lead, antimonial lead, and tellurium lead did not show appreciable differences in corrosion at any of the test sites. The data showed that the corrosion rate of leads tends to increase

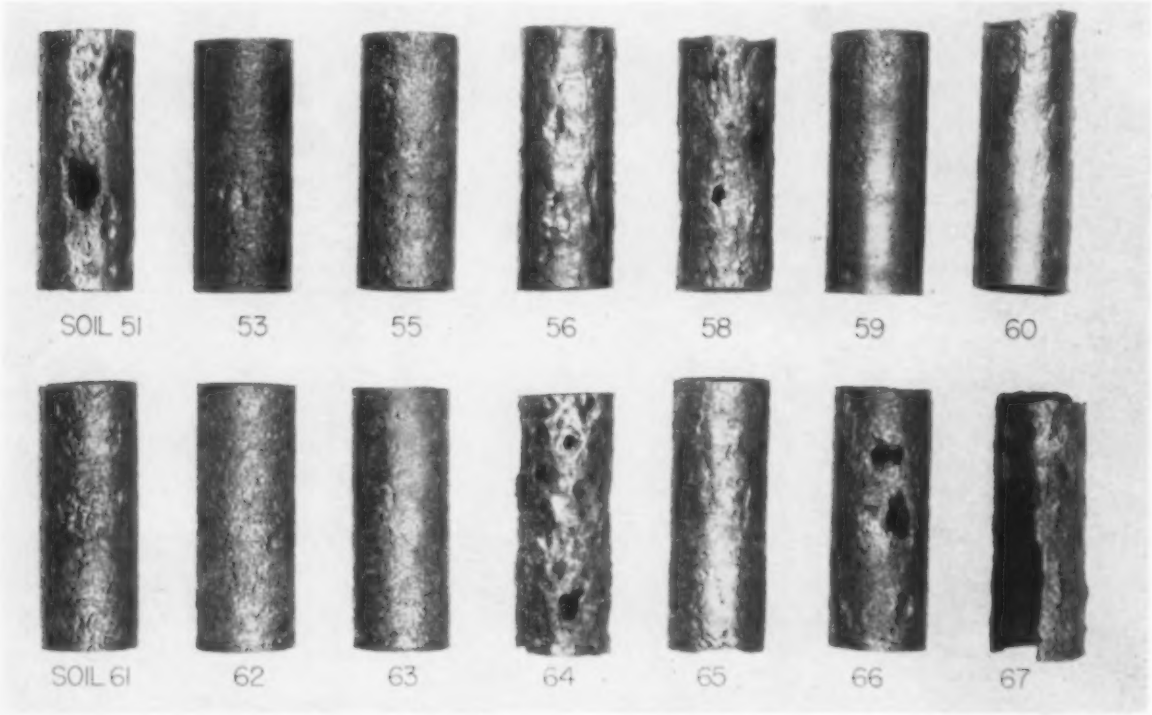


FIG. 8. **Corrosion of plain** carbon steel exposed for approximately 14 years in different soils. Note the differences in the effects of the different soils on the same material.

Soil 51, Acadia clay at Spindletop, Tex.
53, Cecil clay loam at Atlanta, Ga.
55, Hagerstown loam at Loch Raven, Md.
56, Lake Charles clay at El Vista, Tex.
58, Muck at New Orleans, La.
59, Carlisle muck a Kalamazoo, Mich.
60, Rifle peat at Plymouth, Ohio.
61, Sharkey clay at New Orleans, La.
62, Susquehanna clay at Meridian, Miss.
63, Tidal marsh at Charleston, S. C.
64, Docas clay at Cholame, Calif.
65, Chino silt loam at Wilmington, Calif.
66, Mohave fine gravelly loam at Phoenix, Ariz.
67, Cinders at Milwaukee, Wis.

with decreasing aeration of the soil. The presence of organic acidity was found to be corrosive to lead. In soils containing high concentrations of sulfates, chlorides, or carbonates, the lead becomes passivated because of the formation and deposition over its surface of insoluble corrosion products.

To compare the corrosion resistances of plain iron and steel, copper, lead, and zinc, the soils at the test sites were grouped into four environments, as follows: Well-aerated soils, poorly-aerated soils, alkaline soils, and soils high in sulfide and sulfate concentrations. Fig. 10 shows corrosion-time curves for the specimens buried in soils that are typical of each of these environments. It will be noted that plain iron or steel corroded at a considerably higher rate than the other metals in all of the environments except in soil 60. In this soil the corrosion of steel was exceeded by zinc; however, because of its poor aeration, high acidity (pH 2.6), and high sulfate content, none of the materials except lead could be expected to withstand the corrosive action of this soil for a long time.

The curves for soil 64 show, in a general way, the progress of corrosion in alkaline soils (Fig. 10). The curves for soil 53 and for soil 56 show the progress of corrosion in well-aerated and in poorly aerated soils, respectively. In these latter two environments, which are representative of most of the soils found in the United States, copper shows a higher resistance to corrosion than the other metals. This is especially pronounced in the poorly-aerated environment where the corrosion rates of iron or steel, zinc, and lead are proportional to time. In the well-aerated environment, the rates of corrosion of each of the metals decreased rapidly with longer periods of exposure.

Galvanized Coatings

In order to evaluate the effectiveness of galvanized coatings in protecting iron and steel underground, specimens coated with different thicknesses of zinc were included in the Bureau's field tests. The results after 14 years of exposure show that a 2 oz per sq ft coating was sufficient to protect the underlying steel in inorganic oxidizing soils, but in inorganic reducing soils a 3 oz per sq ft coating was required, and highly reducing organic soils require coatings in excess of 3 oz per sq ft.

Steel pipes coated with lead by the hot-dip process, to an average thickness of 0.0015 in., also were buried in the test sites. The lead coatings are cathodic to the underlying steel, and consequently, galvanic corrosion of the steel occurred wherever steel was exposed. The field data showed that the 0.0015-in. lead coatings were penetrated by local corrosion within the first few years of exposure in practically all soils. The data also indicate that in a large number of soils the average penetration of lead by local corrosion is much deeper than the thickness of any coating of lead that is generally applied commercially. Therefore, any consideration of the use of lead coatings for protection of steel in soils must have regard for reduced thickness of the coating by local corrosion.

Somewhat similar conclusions to those found with the lead-coated pipe were observed in specimens of copper tubing coated with less than 0.001 in. of tin by the hot-dip process.

Baked phenolic coatings applied to short sections of steel pipe showed marked superiority to air-dried phenolic coatings in preventing pitting of the steel. The shallow pits that de-

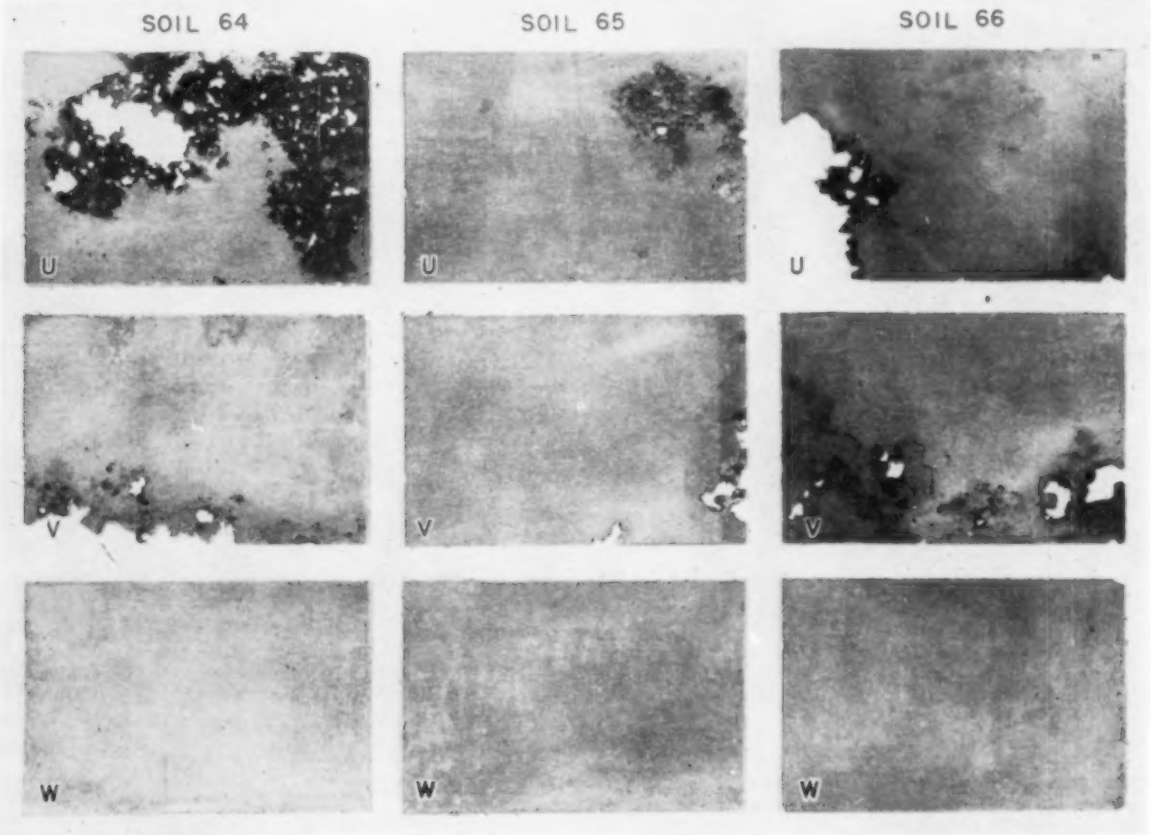


FIG. 9. **Specimens of high-alloy** steels after exposure for 14 years.
U, 12-percent-chromium steel; V, 18 percent-chromium steel; W, 18-percent-chromium, 9-percent-nickel steel.
Soil 64, Docas clay at Cholame, Calif.; soil 65, Chino silt loam at Wilmington, Calif.; soil 66, Mohave fine gravelly loam at Phoenix, Ariz.

veloped under the air-dried coatings showed little tendency to increase with time, perhaps because of the inhibiting action of the zinc chromate that was incorporated into the priming coat of the air-dried coatings.

The distinguishing characteristic of a group of rubber and rubber-like coatings which provided virtually complete protection to the underlying steel, was the unusual thickness of the coating. No corrosion whatever in 13 years was observed on steel covered by soft rubber having a thickness of ¼ in.

The numerous other types of organic coatings included in the field tests did not provide adequate protection to the underlying steel, mainly because of insufficient thickness or because the bond between the coating and pipe was not satisfactory.

Steel pipe coated with vitreous or porcelain enamel showed no evidence of deterioration in 14 years' exposure.

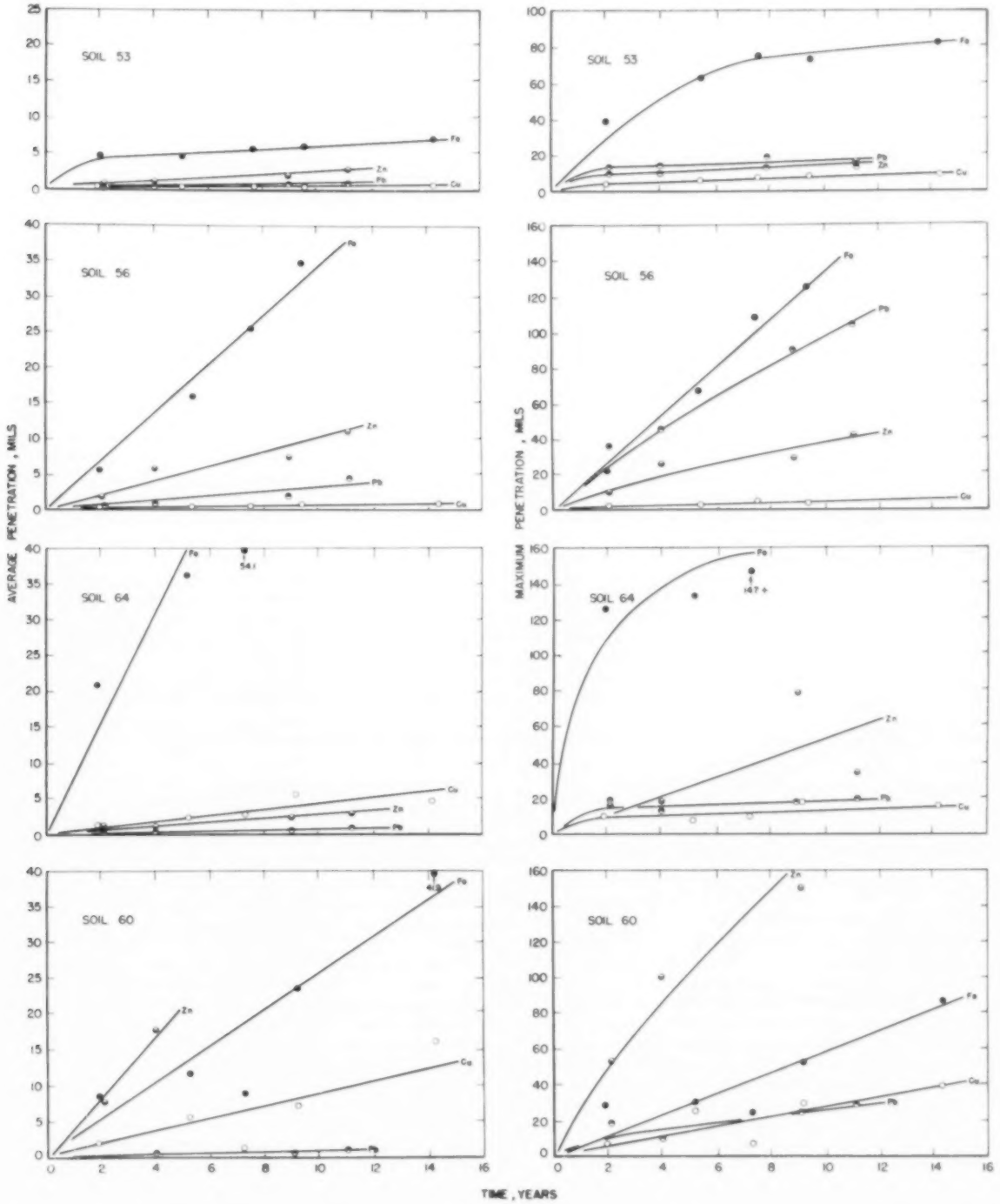


FIG. 10. **Effect of time of exposure** on the average and maximum penetration of iron (or steel), copper, lead and zinc in representative soil environments.

Soil 53, well-aerated Cecil clay loam; soil 56, poorly aerated Lake Charles clay; soil 64, alkaline Dacas clay; soil 60, Rifle peat having a high concentration of sulfate.

Bituminous Coatings Tested

An extensive investigation was conducted between 1929 and 1945 on the behavior of bituminous coatings by the Bureau with the cooperation of the American Gas Association and American Petroleum Institute. Specimens were prepared using every type of bituminous coating material that was on the market at the time, including different kinds of shields, wrappings, and reinforcing materials. These specimens were exposed to soils at 30 test sites and parallel tests were run on sections of nearby operating pipe lines. Some of the early bituminous coatings were too thin, or too soft, or too brittle to provide adequate protection. As a result of this investigation, improved methods of applying coatings to pipe lines were developed; many coatings that were used previously were removed from the market, and new specifications for bituminous coatings were adopted by the industry.

Asbestos-Cement Pipe

In 1937 and in 1939, specimens of asbestos-cement pipe, which has come into wide use for transporting water, were buried at 15 test sites. As this material is nonmetallic, and is not subject to corrosion, the effects of exposure to the soils were evaluated by measurements of mechanical and physical properties, such as hydrostatic bursting pressure, crushing strength, apparent specific gravity, water absorption, and condition of the surface.

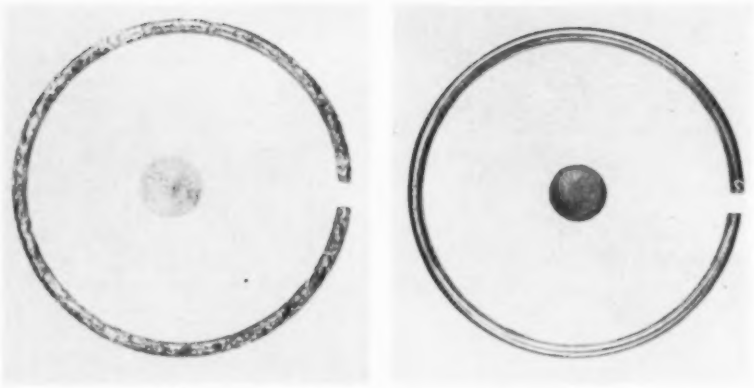
The data for exposures up to 13 years indicated that the asbestos-cement pipe generally increased in strength for several years after burial in the soils. This was associated with a curing process that cement products normally undergo in moist atmospheres.

Following this curing period, the asbestos-cement pipe was subject to loss in strength, decrease in apparent specific gravity, increased water absorption, and some softening of the surface. These effects are accelerated by both organic and inorganic acidity in soils.

Methods and Instruments

Although the Bureau's extensive field investigation of the corrosion of metals underground is generally regarded as its major contribution to the field of soil corrosion, reference should also be made to the development of a widely used code for the inspection of pipes and coatings and to the development and design of methods and instruments for determining the electrical resistivity of soils in the field, such as the McCollum Earth Current Meter, the Wenner Four-Terminal Method, the Megger, and the widely used Sheperd Canes.

The electrical and electrochemical aspects of underground corrosion have been continuously studied in the laboratory. The differential aeration cell developed by Denison and modified by his co-workers has been used to determine the relative corrosivities of different soils and of different metals in the same soil. In other laboratory studies, Schwerdtfeger showed that the instantaneous rate of corrosion at a given time for ferrous metals in soils could be determined quantitatively from polarization characteristics of the metal.



A B

FIG. 11. **Effect of zinc in cathodically** protecting a plain carbon steel underground. Specimens exposed in silt loam at Albuquerque, New Mexico, for 5.8 years.
A, Unprotected steel ring and zinc cylinder; B, steel ring connected to zinc anode. Zinc-steel area ratio, 1:20.

Use of Cathodic Protection

Up to the early 1930's, underground pipe systems were commonly protected from corrosive soils by the use of protective coatings only. Since then, the use of cathodic protection for underground structures has grown rapidly. Bituminous coatings are still used extensively, and in most cases a combination of a protective coating and cathodic protection reduces the cost of maintaining the cathodic protection system.

Cathodic protection consists of impressing electromotive forces on an underground structure through auxiliary anodes, to maintain the entire structure cathodic to the soil at all times. If no current goes directly into the soil from any part of the protected structure, corrosion is prevented.

Currents for application of cathodic protection are obtained from one of two sources. In an area where electric power is available, the current is converted to direct current, if it doesn't exist as such, and auxiliary anodes of scrap iron, carbon, or graphite, or some other material are used as a means of getting the current into the earth. In areas where electric power is not readily or economically available, aluminum, magnesium, or zinc are used as sacrificial anodes to supply the current required to protect the structure.

The Corrosion Section of the National Bureau of Standards has been active in the study of cathodic protection problems, and has contributed substantially to the methods that are in general use today.

In the early development of cathodic protection, Logan and Ewing investigated, both in the field and laboratory, methods for applying and determining the current required to protect underground pipe and tanks cathodically. Holler contributed to the theory of cathodic protection, and Schwerdtfeger investigated various electrical relations involved in cathodic protection. Also, field and laboratory investigations were conducted that aided in determining which soil conditions are favorable for the use of zinc anodes in cathodic protection.

Fig. 11 shows the effectiveness of protecting steel by a sacrificial zinc anode in a silt loam soil after exposure for 5.8 years. It will be noted that the amount of normal corrosion on the unprotected steel ring (Fig. 11-A) is considerably greater than that on the same steel, which was electrically connected to a zinc cylinder (Fig. 11-B), so that the latter behaved as a sacrificial anode.

This concludes the summary of the investigations on soil corrosion that were conducted at the National Bureau of Standards from 1910 to the present. Because of the limited space and the vast amount of material to cover, it has been possible to present only briefly abstracts on some of the topics involved in the investigation.

The National Bureau of Standards Circular 579* will be available from the Superintendent of Documents and will supersede the Bureau's Circular 450, issued in 1945. Circular 579 is a record of the Bureau's investigations on the corrosion of metals in soils.

*M. Romanoff, Underground Corrosion, Circular of the National Bureau of Standards 579. Requests for notification of availability of the circular may be sent to the author. ★ ★ ★

P 615.635

This is the second of a group of articles assembled by George B. McComb for industry members to provide a collection on pipe protection methods for use as reference material. The first was published in *The Pipeline Engineer's* March 1957 issue. Eventually, the material published here will be combined with selected material previously published and issued in several "Bound Collections."

AN ECONOMIC STUDY OF

Underground Corrosion Preventive Measures

A study of economic principles as applied to underground corrosion preventive measures in general cites maintenance cost and leak experience on a bare Texas Gulf Coast trunk pipeline, prior to application of cathodic protection, and the fundamentals of operation of the system for 15 years. Data indicate that preventive measures for bare pipe are effective and less expensive for the first 15 years' operation than reconditioning, coating and application of cathodic protection to supplement coating.

This paper also indicates results of a survey of 28 leading pipeline companies, reporting miles of pipe laid during the period 1930 to 1955; type of protective coating used, if any; percent of total length of lines protected by coating and/or cathodic protection; cost of coating materials and application cost; average cost of power for cathodic protection by rectifier; estimated cost of protection by galvanic anodes on a per-mile-per-year basis; and effectiveness of cathodic protection as indicated by leak experience.

Dean Glass

Pure Transportation Company
Chicago, Illinois

As operators of pipelines, underground power-transmission lines, and other buried metallic structures, we are interested in operating costs. Basic economic principles apply to all businesses, and in pipeline operations they include the additional problem of corrosion.

In the pipeline industry we recognize that losses have been great as a result of faulty planning of corrosion preventive measures, and that an attempt should be made to better evaluate the economics of each measure.

It appears that one basic problem of economics for the corrosion engineer is to bridge the gap that exists between our recommendations to management for the protection of underground lines and management's approval to proceed with the work.

Progress in Corrosion Engineering

Research is firmly established as an essential activity of successful industry. No longer is there a question as to whether research in corrosion engineering should be done, nor is there a question as to how it should be done. The techniques are fairly well established. The real question is: What specific projects should be developed? Looking at our own progress and preventive measures, we question our advancement within the past 25 years. We have learned that it is essential to have complete records for determining the cost of leaks, cathodic protection, and coating; that, on an unprotected line, the leak-frequency curve follows a logarithmic sequence; that, in determining these costs, we must evaluate loss of line revenue during downtime, property damage, and commodity losses and that we must reduce such losses by means other than pipe replacement, as was originally done by most companies.

In referring to our 25 years of advancement, we include cathodic protection as an underground corrosion preventive measure; yet what do we mean? What is protection? What are the criteria? What is the best coating for a given job?

We have shown by operating experiences that pipe coatings and cathodic protection can be used successfully and economically to prevent or minimize corrosion of our pipelines. It is generally agreed, and can be shown by laboratory methods, that electrolytic corrosion of steel will cease when direct current flows uniformly to the exposed surface of steel.

The pipeliner's problem is to determine when such conditions exist in the field. It is my opinion that more research should be conducted along the pipeline right-of-way, and less in a laboratory or in the home office.

Yardstick for Underground Protection

We pipeliners do not wish to become deadlocked in an argument with corrosion engineers as to what constitutes protection. However, we use a 0.30-v change of potential, a minimum of 0.85-v pipe negative to soil (when referred to a copper-sulfate electrode), the Null Method, the Remote Electrode Method, and many other methods not evaluated by years of experience, in attempting to determine when our underground pipelines are protected. Experience over many years indicates that 0.85-v pipe (negative to soil when measured with a high-resistance voltmeter, and when an electrode is placed over the pipe) will retard corrosion. This figure seems to be favored by the pipeline industry.

Presented to the sixth annual spring products pipeline conference and field trip, under the auspices of the American Petroleum Institute's Division of Transportation, Chicago, Illinois, May 16, 1955.

As mentioned previously, we cannot accurately measure in the field current density on pipe surfaces, and we have no sure means, other than leak records, for determining corrosion rates. Such indication comes after much damage has been done to the pipe. At our cathodic-protection installations we measure the total current flowing to a known length of pipe or area of steel; we can then compute average current density. When active corrosion occurs in soils of uniform resistivity, we have also found that there is a decided uniform distribution of current. Again, what does this mean? How can these data be used on our next project?

With further reference to underground corrosion preventive measures and yardsticks, there has been much discussion throughout the years of soil-survey methods as indications of the need for pipeline coatings or cathodic protection. If survey data are reliable they can be a valuable guide toward defining areas where cathodic protection or coatings are required. If it is deemed sound economy to gather these data, they must be utilized effectively in designing protective measures, otherwise they only satisfy engineering curiosity.

The satisfaction of engineering curiosity may be necessary for the development of more reliable soil-resistivity testing methods. In practice there is some question as to the justification of the survey, however. Some companies deem it advisable to invest in protective measures throughout the length of line rather than to attempt to spot-protect a pipeline on the basis of soil survey data.

Considerations for Design of Facilities

The foregoing inferences regarding various methods of testing prior to application of cathodic protection or coatings may be confusing. Our experience shows that most trouble encountered in corrosion prevention starts with faulty planning of the initial project, however. If we kept this foremost in mind when estimating current requirements and selecting coating materials — instead of using questionable survey methods, low first cost of coatings, and promotional policies to sell inferior products — we should save many pipeline failures and many dollars in unnecessary maintenance costs. After all, each of us has company requirements to meet, and these requirements can be studied only as applied to a special situation.

Data Necessary for Evaluation of Underground Corrosion Preventive Measures

It is always necessary for us to submit preliminary cost estimates of proposed pipelines in order to establish the feasibility of the new project or to compare various proposals for corrosion preventive measures.

The type of information most needed is original cost data, which can be acquired only by our experience, correspondence with outside companies, or exchange of information at meetings such as this. Therefore, it is the aim of this paper to present factual information concerning original and operating costs of typical facilities used for corrosion prevention. In comparing the economics of protective measures, we must consider important variables, such as types of coating materials, coating thickness, wrappers, geographical location of pipelines, season during which construction is performed, size and type of pipeline, service life expected, special tax situations, maintenance costs, plans for cathodic protection, and whether we are dealing with an existing line or new construction.

PART I.

Typical Engineering Economics

Protection of a Trunk Pipeline

Our profession as pipeliners broadens in scope with each succeeding year, but the fundamentals of our operations remain the same. To illustrate some economic factors previously mentioned, let us look at a typical pipeline of Pure Transportation Company.

The example to be cited is a crude oil trunk pipeline laid in 1930 from Van, Texas, to Smiths Bluff Refinery of The Pure Oil Company, Nederland, Jefferson County, Texas. This line was constructed from new 10¾ in. OD pipe weighing 34.24 lb per ft (wall thickness 0.307 in.) and delivered in 30-ft lengths, with double bell-end joints equipped with "chill rings." The electrical welding process was used to join the pipe in the field.

This line was buried an average depth of 20 in. and laid bare, as it was the consensus at the time of construction that no coating was necessary, and that corrosion would be taken care of by the wall thickness of the pipe. The system was designed to operate at a maximum pressure of 1000 psi and a capacity of 45,000 bbl per day.

Early maintenance history. The first leaks on the trunk line developed in 1936 on the 18-mile section through irrigated rice country and, by 1938, 10 leaks had occurred, resulting in considerable loss of oil. These operating difficulties called management's attention to the immediate need for investigating the possibilities of external corrosion prevention.

Inasmuch as this line was the main feeder for a refinery, it could not be taken out of service for extended periods; therefore, the company was faced with the problem of line protection in place.

Results of current requirement tests. Current requirements for protecting a given length of bare pipe of the system were not known, and experiments were conducted to determine the feasibility and possible advantages of cathodic protection.

Experimental data indicated that three rectifier installations per mile would be required to obtain the optimum current distribution necessary for raising pipe-to-soil potentials approximately 0.3 v (pipe negative to soil, with copper sulfate electrode over pipe). No attempt was made to determine the criterion for complete cathodic protection. However, it was assumed that corrosion would be stopped if this potential difference was maintained.

Based upon test results, approximately 40 amp of direct current per mile would be necessary to protect one 10-in. bare pipe.

Coating and reconditioning cost prior to application of cathodic protection. The cost of reconditioning and coating several hot spots with asphalt, as performed with existing equipment from 1936 to 1937 on other sections of the trunk line, approximated 97 cents per lineal foot of pipe. This method was originally employed in an endeavor to stop pipe corrosion. However, experience indicated that, when used alone, this method was entirely inadequate and recurrence of the coating operation could be anticipated.

The system continued to develop leaks; 5 occurred in 1938, 10 in 1939, and, while results of the test installation were being awaited, hot-spot reconditioning and coating continued through 1938 and 1939 on sections of the line other than irrigated coastal country. Coating specifications had been changed from asphalt to coal-tar enamel, with 3/32-in. average thickness of coating and one 15-lb tar-saturated outer wrap.

Economic analysis of the problem and decision. Inasmuch as little progress was made toward stopping the leak frequency by the hot-spot reconditioning program, it was recognized that corrosion prevention experiments, as conducted, were costly and would require years for developing facts.

This operating department project for the coastal area resolved into: (1) The immediate investment of approximately $50,000 for cathodically protecting 18 miles of bare pipe at the risk of considerable loss (because effectiveness of the installation could only be assumed); (2) the investment of a minimum of $100,000 in reconditioning and coating this section, with prospects of small yearly operating expenses for added protection.

The course of action for this project was directed toward application of cathodic protection to the pipeline in place, inasmuch as a minimum cash outlay was required and the problem of handling a "loaded" line was eliminated.

As a result of the study, it was decided, in 1939, to apply cathodic protection to the Gulf Coast section. This required construction of an a-c power-distribution line parallel to pipeline and installation of 50 small capacity rectifier units for the d-c source. The system was placed in operation in 1940.

Operating Experience — Bare Section, Coastal Area

1. Leak experience. A study of leak records for the bare section under cathodic protection since January 1, 1940, indicates that a total of eight leaks have occurred at three different locations. At one location leaks had occurred prior to application of cathodic protection, and six of the total of eight leaks occurred at sites where the pipe was known to have been severely corroded and replacement of the pipe seemed inevitable unless corrosion could be stopped. Two of the six leaks occurred within a few months after cathodic protection was applied, and it is reasonable to assume that they occurred coincidental with increase of line pressures. Two leaks occurred in 1943, one in 1946, and two in 1947, all in the same vicinity. The last leak to occur on the bare section was in 1948, despite poor condition of the pipe when cathodic protection was applied. No other leaks have developed on any section of the pipeline where cathodic protection was applied in 1940.

2. Cost Data. The total cost of providing cathodic protection for the 18 miles of 10-in. bare pipe from 1940 through 1954 is broken down as follows:

Installation (1939)	$ 46,241.45
Maintenance	67,789.73
Power	14,922.95
Total cost	$128,954.13
Cost per mile	$ 7,164.12
Cost per mile per year	477.61

Operating Experience — Coated Section

Inasmuch as measures had been taken in 1940 to protect the trunk line in the coastal area, it was deemed advisable in 1943 to complete protection of the entire system by reconditioning, coating, and wrapping the remaining 186-mile section of 10-in. pipe. This work was completed in 1945 at an average cost of $1.29 per lineal foot of pipe.

The total cost of reconditioning, coating, and providing cathodic protection for 186 miles for the 10-year period from 1945 to date is as follows:

Coating and wrapping	$1,276,883.20
Rectifier installation	5,743.00
Cathodic protection maintenance	3,867.71
Power	6,932.96
Total cost	$1,284,426.87
Cost per mile	$ 6,905.52
Cost per mile per yr.	690.55

As the foregoing is a 10-year actual-cost statement for protection of the coated pipe, we can extrapolate these data for five more years to compare them with costs for protecting the bare section for a 15-year period. Assuming that maintenance and power costs will remain constant for five more years, the cost per mile per year is reduced from $690.55 to $462.30. It thus appears that, in this case, *15 years is the breakeven point,** after which it will be more economical to protect the coated pipe even though a cash expenditure of $1.29 per ft is necessary for reconditioning and coating.

*No consideration is given to special tax situations or financing.

PART II.

Results of Industry Survey of Pipeline Construction

Coating Practices and Cost of Corrosion Preventive Measures

In order to compile cost data and to indicate industry trends toward the protection of underground structures, a survey was made by the author on behalf of the American Petroleum Institute's Committee on Pipeline Technology. Made in 1955, this survey included typical member companies operating crude and products pipelines and now provides a yardstick for economic analysis of various protective measures.

For analysis or comparison of methods we have no known means for estimating uncontrolled corrosion on pipelines; it is, therefore, difficult to estimate savings that we have achieved by our preventive measures.

The costs of corrosion prevention as indicated in Tables 1, 2, 3, and 4 have been made available by a cross-section of the pipeline industry; they provide average costs for coatings and cathodic protection for the years 1930 through 1954, based upon pipe sizes from 4 in. through 26 in., inclusive.

Thirty-two companies were solicited for data on construction and operating practices as related to corrosion preventive measures, and replies were received from 28 companies representing a large percentage of the entire products pipeline and crude oil industry. Data submitted by these companies were analyzed and Tables 1 through 4 compiled.

Table 1 indicates the trend, by percent, toward specific types of coatings used and the average cost per lineal foot of pipe coated.

From Table 2 it is evident that more consideration was given to the necessity of coating pipe sizes from 4 in. through

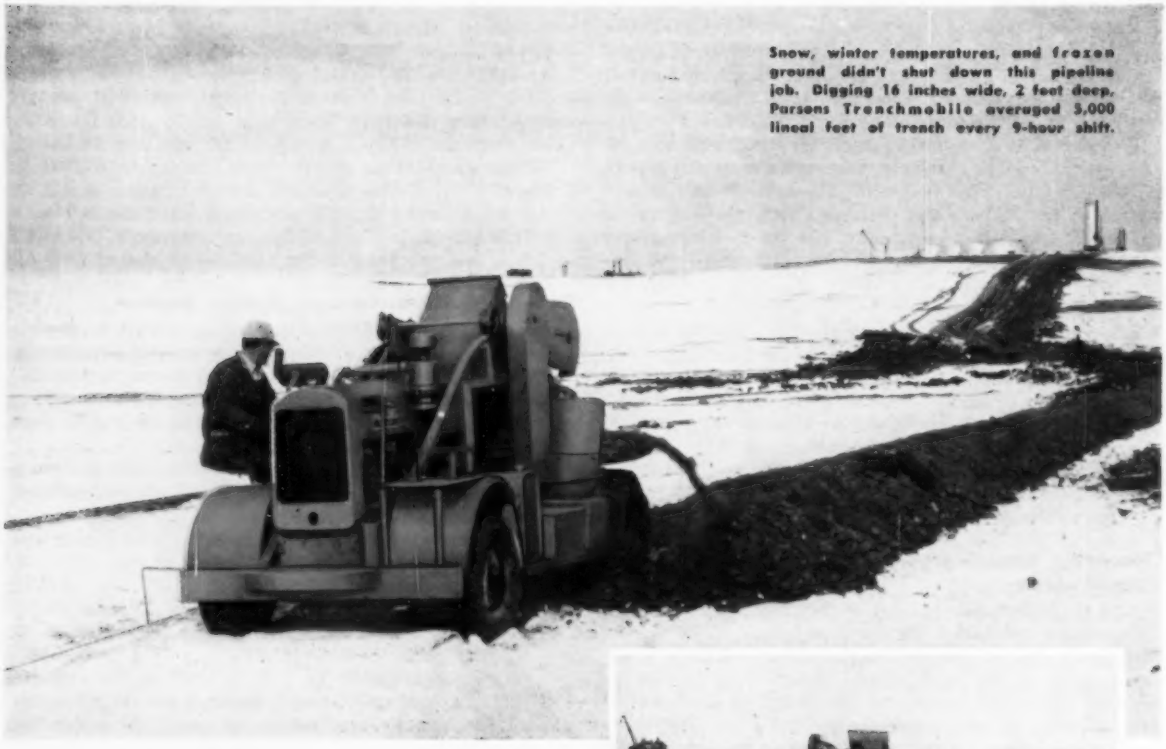
TABLE 1. Pipe Laid Through Period 1930 to 1940 — Data Indicating Pipeline Coating Practice and Cost

Pipe size, (in.)	Number of miles laid	Bare, percent	Coal tar, percent	Asphalt percent	Asphalt mastic percent	Wax or grease percent	Other percent	Geographical location* percent	Average cost of coating† per lineal foot, cents
4	254	55	0	45	0	0	0	95 SW	...
6	2,352	82	2	11	0	0	5	60 SW to 35 MW	19.5
8	3,420	45	7	17	1	2	28	45 SW to 50 MW	17.0
10	740	7	10	76	0	7	0	90 MW	29.0
12	707	5	0	82	13	0	0	85 MW to 15 WC	34.0
14	15	0	0	100	0	0	0	100 MW	...
16	5	20	0	0	80	0	0	100 WC	42.0

Note. Of coated pipe listed 99.7 percent was coated over the ditch during construction.

*Abbreviations for geographical locations: SW = Southwest, MW = Midwest, WC = West Coast, etc.; and only areas containing the largest percentage of pipe are listed.

†Includes material and application.



Snow, winter temperatures, and frozen ground didn't shut down this pipeline job. Digging 16 inches wide, 2 feet deep, Parsons Trenchmobile averaged 5,000 lineal feet of trench every 9-hour shift.

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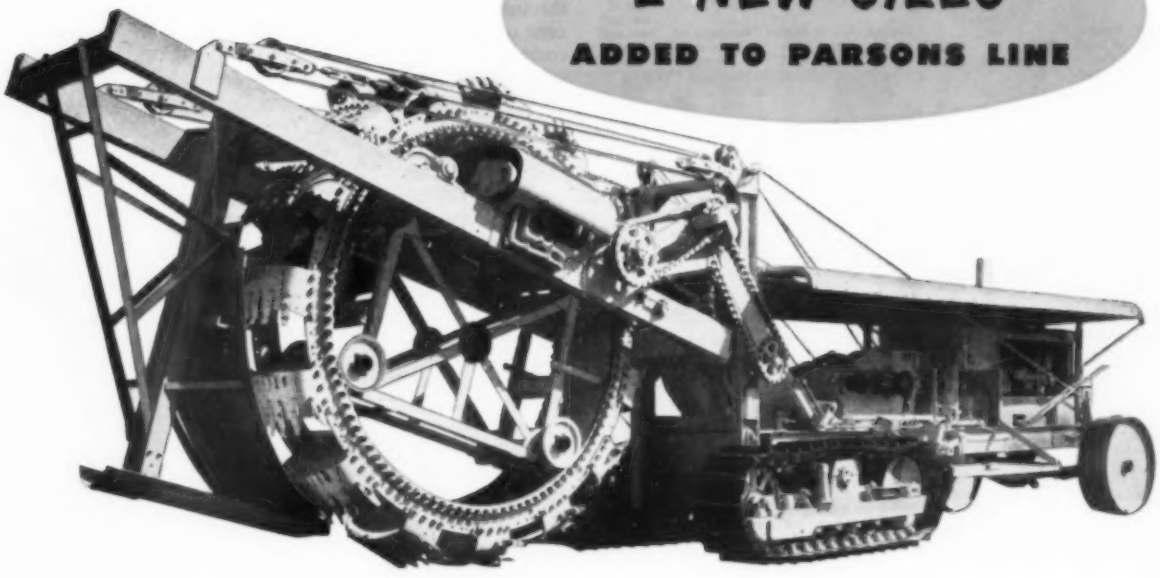

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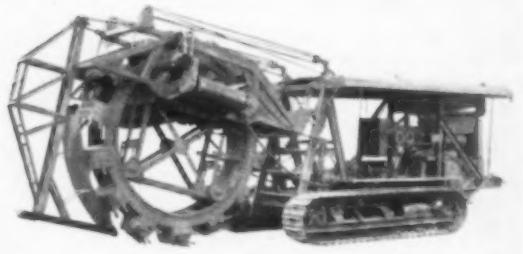

As an auxiliary production unit to the Big and Middle-Inchers, this smaller wheel-type 150 Trenchliner digs laterals, gathering-lines, etc., at speeds up to 25 feet per minute. It opens trench 16 to 30 inches wide, 5¾ feet deep. Hydraulic wheel-hoist gives infinite depth adjustments — maintains close grade tolerance.

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TABLE 2. Pipe Laid Through Period 1940 to 1950 — Data Indicating Pipeline Coating Practice and Cost

Pipe size, (in.)	Number of miles laid	Bare, percent	Coal tar, percent	Asphalt percent	Asphalt mastic percent	Wax or grease percent	Other percent	Geographical location* percent	Average cost of coating† per lineal foot, cents
4	402	61	2	21	0	16	0	63 SE to 19 SW	15
6	1,976	15	37	19	20	6	3	55 MW to 22 E	23
8	5,652	22	41	19	16	2	0	38 MW to 33 SW	29
10	2,538	53	19	21	4	3	0	44 SW to 27 MW	30
12	2,622	16	25	50	7	1	1	45 SW to 31 MW	37
14	21	0	12	88	0	0	0	100 MW	...
16	1,028	0	2	98	0	0	0	80 SW to 18 MW	44
18	215	0	0	18	62	0	20	82 WC to 18 MW	54
20	1,304	0	59	41	0	0	0	86 MW to 14 SW	62
22	158	0	0	48	52	0	0	100 MW	75

Note. Of coated pipe listed 89 percent was coated over the ditch during construction.

*See footnote, Table 1.

†See footnote, Table 1.

TABLE 3. Pipe Laid Through Period 1950 to 1955 — Data Indicating Pipeline Coating Practice and Cost

Pipe size, (in.)	Number of miles laid	Bare, percent	Coal tar, percent	Asphalt percent	Asphalt mastic percent	Wax or grease percent	Other percent	Geographical location* percent	Average cost of coating† per lineal foot, cents
4	326	15	84	0	0	1	0	72 SW to 27 NW	21
6	706	5	77	15	3	0	0	67 SW to 21 NW	38
8	2,787	3	71	20	6	0	0	46 MW to 27 NW	33
10	2,225	15	68	9	8	0	0	45 SW to 43 MW	37
12	3,365	0	85	8	6	1	0	75 MW to 24 SW	50
14	690	13	87	0	0	0	0	66 SE to 27 E	...
16	507	0	74	26	0	0	0	62 SW to 19 NW	48
18	454	0	100	0	0	0	0	95 SE	56
20	603	0	58	42	0	0	0	72 SW to 21 NW	54
22	379	0	36	64	0	0	0	65 SW to 35 NW	56
24	321	0	22	78	0	0	0	99 SW	58
26	493	0	100	0	0	0	0	100 SW	50

Note. Of coated pipe listed 92.3 percent was coated over the ditch during construction.

*See footnote, Table 1.

†See footnote, Table 1.

8 in. during the years 1940 to 1950 than in the preceding 10-year period, because only 22 percent was laid bare. This 22 percent also applies to pipe sizes from 10 in. through 22 in. during the period 1940 to 1950. This increase in percentage of large-diameter pipe laid bare may be attributed to construction practices dictated by wartime conditions.

Table 3, for the pipeline construction period from 1950 to 1955, indicates that only 4.4 percent of pipe sizes from 4 in. through 8 in. was laid bare. Through the same period 4.7 percent of pipe sizes from 10 in. through 26 in. was without coating.

Perusal of Tables 1, 2, and 3 will show the average cost per lineal foot of coatings for pipe sizes from 4 in. through 26 in. for the period 1930 to 1955. It is difficult to compare coating costs indicated in the three tables because consideration must be given to various coating materials and methods of application.

Table 4 has been prepared to show cost data for cathodic protection by rectifier and/or galvanic anodes for coated and bare pipe. Because data submitted did not, in all cases, include line size, type of coating, and geographical location, a detailed analysis of cathodic protection costs was not possible.

The rectifier costs shown are for power only and do not include depreciation and maintenance of the system. The cost indicated for magnesium anodes includes first cost of magnesium, installation costs, and depreciation, assuming a 10-year life.

Table 4 also indicates miles of pipeline reported, percent of system under cathodic protection, and leaks occurring per year. A leak frequency per 100 miles per year (1954) has been calculated for comparison with other systems reporting their various protective measures and leaks.

This table shows also the average cost per leak as reported and, in comparing leak costs, it is believed of interest to operators of products lines to note that leaks in products systems are approximately five times the cost of crude oil leaks. However, we should not lose sight of the fact that a single leak could cost thousands of dollars in property loss and damage claims and in no manner could be compared with the average cost shown.

In this paper it has not been deemed advisable to make an attempt at evaluation of various types of coatings as to performance, nor to compare the economics of lower first-cost coatings and resulting higher maintenance costs with high initial construction costs and low maintenance.

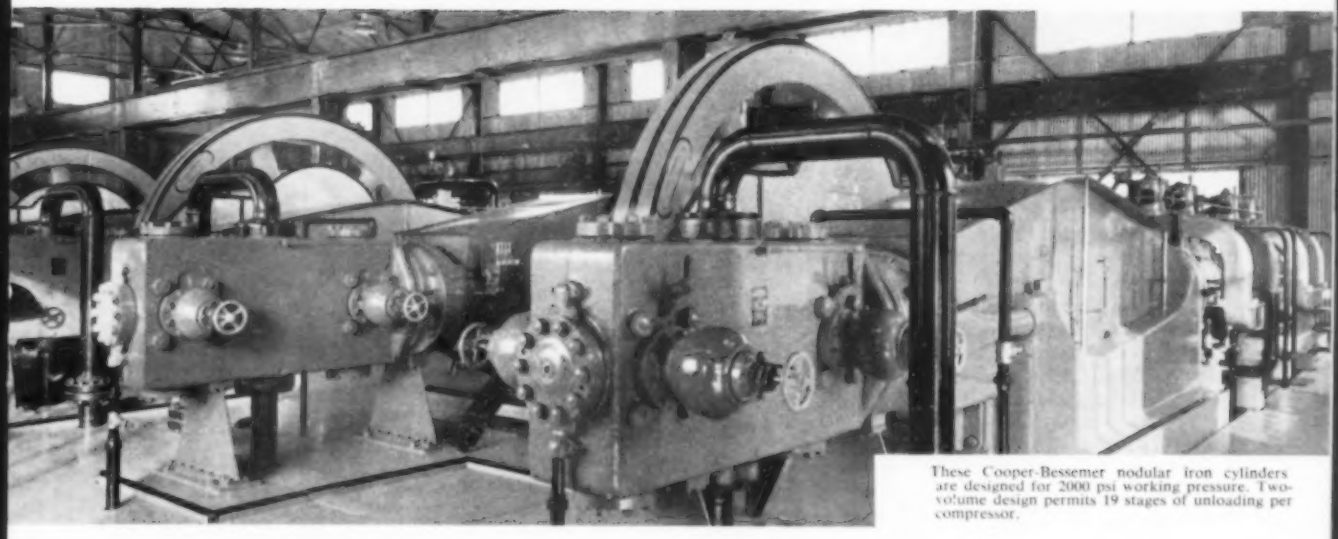
TABLE 4. Summary of Cost Data *—Power Cost for Cathodic Protection and Leak Experience

Source of data (Company No.)	Length of pipeline system, miles	Amount of system having cathodic protection, percent	Number of leaks per year	Leak frequency, per 100 miles per year	Cost per leak, dollars	Rectifier power cost for coated pipe, dollars per mile per year	Rectifier power cost for bare pipe, dollars per mile per year	Magnesium-anode cost for coated pipe, dollars per mile per year	Magnesium-anode cost for bare pipe, dollars per mile per year
1	2253.82	17	1207	54.9	432	8.44	8.44	10.00	10.00
2	1172.50	91	0	0	...	2.70	...	80	...
3	445.00	100	0	0	...	1.20	...	...	...
4	546.00	100	0	0	...	6.62	...	...	...
5	1348.00	38	200	14.9	175	10.60	...	16.30	...
6	9120.00	30	1602	17.6	750	18.00	...	...	...
7	2061.00	82	5	.2	2500†	18.38	22.75	...	...
8	1195.80	...	75	6.3	...	1.00	4.70	...	...
9	763.20	100	1	.1	...	1.22	...	5.67	275.04
10	1578.00	50	...	...	...	...	125.00	...	250.00
	2628.00	100	...	...	...	3.00	...	...	...
	2400.00	...	25	1.0	1600†	...	...	...	...
11	1152.29	...	...	...	...	5.30	...	5.17	...
12	195.00	100	0	0	...	1.10	...	...	...
13	625.00	18	...	...	...	11.18	87.38	...	...
14	573.00	65	130	22.6	130	...	...	...	...
15	98.35	100	0	0	...	3.15	...	...	...
16	9078.00	65	216	2.4	865	...	...	...	...
17	9244.00	31	539	5.4	...	...	46.00	25.00	...
18	268.50	100	0	0	...	.64	...	3.11	...
19	485.00	100	7	1.4	1555†	...	61.80	...	...
20	1043.00	99	1	.1	250	29.50	...	20.00	...
21	2140.00	87	2	.9	1600†	1.20	...	1.34	...
22	427.00	1	20	4.7	300	...	...	...	150.00
	569.00	86	1	.2	300	...	...	10.00	...
	75.00	20	...	...	...	...	...	...	...
23	77.00	100	1	1.3	1350†	6.24	90.00	...	...
24	5313.00	55	165	3.1	1686†	11.43	...	...	161.00
25	414.20	100	2	.5	400	4.39	...	...	...
26	6040.00	45	242	4.0	...	8.08	15.05	47.30	127.50
27	211.00	100	0	0	...	3.33	73.33	...	...
28	...	100	0	0	...	...	...	...	...

*Data submitted did not indicate line sizes; all data includes 4-in. through 26-in. diameter lines.
†Indicates products pipelines.

WITH **NODULAR IRON** CYLINDERS

DESIGNED FOR 2000 PSI SERVICE . . .



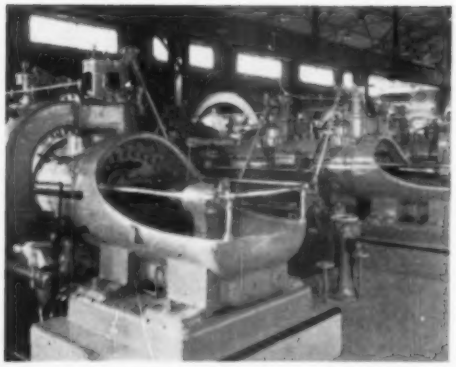
These Cooper-Bessemer nodular iron cylinders are designed for 2000 psi working pressure. Two-volume design permits 19 stages of unloading per compressor.

COOPER-BESSEMER ADDS "NEW LIFE" TO OLD COMPRESSORS

At the Rockport and Ripley compressor stations of United Fuel Gas, Charleston, West Virginia . . . nodular iron cylinders have "up dated" 25 to 30 year old Cooper-Bessemer twin-tandem horizontal compressors.

These new Cooper-Bessemer nodular iron cylinders provide greatly increased flexibility while keeping the units at full capacity over a wide range of pressure conditions. Gas to storage is handled at 620 to 685 psi suction and 1000 to 1800 psi discharge. Delivery from storage is at 300 to 700 suction and 800 to 950 discharge.

If you are open to ideas on cutting costs and improving the efficiencies of your older compressor installations, be sure to check with Cooper-Bessemer.



Cooper-Bessemer Type-22 engines in the United Fuel Gas Company's Ripley, West Virginia station.

BRANCH OFFICES: Grove City • New York • Chicago Washington • San Francisco • Los Angeles • Houston • Dallas Odessa • Pampa • Greggton • Seattle • Tulsa • St. Louis Kansas City • Minneapolis • New Orleans • Shreveport • Casper

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PART III.

Pipeline Industry Specifications with Respect to Mill or Yard Applications of Coatings and Wrapper Materials

As an indication of trend toward customer demand for mill or yard application of coating and wrapping materials for pipe size from ¾ in. through 26 in., leading yard applicators were solicited, and their reports indicate that for all pipe yard coated:

1. Ninety percent of customers specify coal tar.
2. Forty percent specify one wrap of 15-lb asbestos felt.
3. Twenty-nine percent specify one wrap of glass-type wrapper.
4. Thirty-one percent specify one inner wrap of glass type and one external wrap of 15-lb asbestos felt.

Based upon the above data for the period 1951 through 1953, it is evident that customer demand with respect to yard application of coating materials is toward the coal tars, and approximately 40 percent of customers specify a single wrap of 15-lb asbestos felt.

Conclusions

Part I: The principal conclusions, based upon an economic survey of Pure Transportation Company's facilities, which have been cited, are:

1. Operating experience of 15 years in the Texas Gulf Coast area indicates that it is economically feasible to protect a bare 10-in. pipeline by cathodic protection. Protection is effective as evidenced by the fact that the occurrence of leaks has been stopped.
2. The initial investment for corrosion prevention by cathodic protection of the 10-in. line cited is approximately 50 percent of that required for reconditioning and coating.
3. The initial investment and operating expenses of cathodic protection installations for 15 years equals the estimated cost of reconditioning, coating, and supplementing coating with cathodic protection.
4. Many pipeline failures and maintenance expenses can be eliminated by proper initial design of facilities.
5. For economic appraisal of various corrosion preventive measures we must consider initial investment, interest, depreciation, operating expenses, special tax situations, percent return on investment, and engineering and operation requirements as dictated by the specific problem.
6. An essential condition for success of a corrosion preventive program is a cooperative attitude on the part of company executives. They must believe in the need for corrosion prevention and must give financial and moral support to it.

Part II: From analysis of industry survey data indicated in Tables 1, 2, 3, and 4 concerning 63,500 miles of pipelines laid, it can be concluded that:

1. From 1930 to 1940:
   A. Forty percent of pipe was coated (4-in. through 8-in. diameter),
   B. Ninety-four percent of pipe was coated (10-in. through 16-in. diameter).
2. From 1940 to 1950, 78 percent of pipe was coated (4-in. through 26-in. diameter).
3. From 1950 to 1955, 95 percent of pipe was coated (4-in. through 26-in. diameter).
4. From cost data submitted, an average cost of a specific coating cannot be determined because of the number of variable factors.
5. From Table 4, cost data available indicate that rectifier power cost per mile per year for cathodic protection of coated lines average $7.12, and the median power cost per mile per year is $4.85.
6. Rectifier cathodic protection power cost per mile per year for bare pipe shows an average of $53.41 and median of $53.90.
7. Indications are that one-half of reporting companies have more than 90 percent of their facilities under cathodic protection.

Part III: Based upon data for the period 1951 through 1953, a survey* of leading yard applicators indicates:

1. Ninety percent of customers specify coal-tar coatings.
2. Forty percent specify a single wrap of 15-lb asbestos felt.
3. Twenty-nine percent specify a single wrap of glass-type wrapper.
4. Thirty-one percent specify a single inner wrap of glass type and one external wrap of 15-lb asbestos felt.

Acknowledgment

Special thanks are due O. L. Entrekin and J. A. Wisdom of Pure Transportation Company for suggestions and aid in preparation of the cost data.

*Survey excludes asphalt-mastic yards.

The following companies have contributed much information that was necessary for the preparation of this paper:

Arkansas Pipeline Corporation
The Buckeye Pipe Line Company
Cities Service Oil Company
Detroit Southern Pipe Line Company
Great Lakes Pipe Line Company
Gulf Refining Company
Hill, Hubbell and Company
Humble Pipe Line Company
Imperial Oil, Ltd.
Interstate Oil Pipe Line Company
Magnolia Pipe Line Company
The Ohio Oil Company
Pan American Pipe Line Company
Phillips Pipe Line Company
Pipe Line Service Corporation
Plantation Pipe Line Company
Pure Transportation Company
Salt Lake Pipe Line Company
Service Pipe Line Company
Sinclair Pipe Line Company
Socony Mobil Oil Company, Inc.
Sohio Pipe Line Company
Southeastern Pipe Line Company
Standard Oil Company (California)
Standard Oil Company (Indiana)
Standard Pipeprotection Inc.
Sun Pipe Line Company
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The Texas Pipe Line Company
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Dresser Split Repair Sleeves are a quick, efficient means of repairing breaks, splits, holes and other failures in pipe lines. Easy to install. No loose parts —no welding. Self-sealing end-gasket pressure increases as line pressure increases. Sizes 6″ through 24″.

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Dresser Porous Weld Clamp stops leaks fast, without shutting down the line. Simply put it around the weld and draw up the bolts. You get a permanent repair in a matter of minutes. Sizes 2″ through 31″.

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Style 111

REINFORCING SLEEVES

Now available from Dresser in the best grade flange-quality steel plate. Uniformly perfect shaping assures easy installation. Vented against pressure build-up. Order Dresser Welding Sleeves for welded lines, Weld-over Sleeve for coupled lines. Can be furnished in special sizes and shapes when production quantities are involved.

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CHRONOLOGY Of The Pipeline Industry

Donald M. Taylor,
Gulf Coast Editor

Frank H. Love,
Editor

LAST year the U. S. consumed more than 10 trillion cu ft of natural gas. This amount would blanket the states of Texas, Oklahoma, and Louisiana (the leading gas producers) with a layer of gas one foot deep and have enough left over to cover most of West Virginia (which is one of the birthplaces of the gas industry). And, figuring its weight at 1/20 of a pound per cubic foot, it would weigh better than 250,000,000 tons, or almost twice the weight of all the steel produced in our country last year!

Virtually all of this gas moved from wells to its point of consumption through a vast network of pipelines totaling about 450,000 miles (including distribution lines).

Our crude and petroleum lines are equally amazing. Last year the U. S. consumed more than two tons of petroleum per capita and a large portion of this amount traveled a part of the distance from source to ultimate consumer through pipelines. Our crude lines that link oil wells and refineries now total something like 190,800 miles, and our products lines that carry gasoline, fuels, etc., to distribution points now total 39,225 miles.

This amazing industry's growth has been firmly rooted in the simple economic fact that pipeline provides the most inexpensive means of transportation. Despite its massive size today, it is a young industry destined to flourish only so long as it continues to provide the most inexpensive means of transporting the contents of the lines to destination.

Although the pipeline industry has shown an almost explosive growth in recent years, it actually dates from ancient times. Indeed, pipe is one of man's oldest inventions, its discovery probably preceded only by the hatchet, spear, and bowl.

Here are the historical highlights that have lead to the intricate technology of modern pipelining:

5000 B.C.

It was probably about this time that the ancient Chinese constructed the first pipelines of bamboo to pipe water from hillside streams and springs to their homes, villages, and fields. They buried the bamboo stalks, joining them with clay or pitch to minimize leakage and evaporation.

4000 B.C.

The greatest impetus for pipelines came in countries where evaporation and absorption losses of water made it desirable to bury the lines. This called for an impervious and structurally strong pipe. In ancient Babylon, men began making pipe by firing tubes of clay. They buried these beneath the ground to transport water from springs and streams. In the years that followed this practice, they devised pipe fittings including tees and ells, the better to pipe homes and temples.

3000 B.C.

The earliest metal pipe was made of copper. One specimen found in the Temple of Abussi in Egypt is said to be about 5000 years old.

1500 B.C.

Archeologists say the royal city of Crete had a pipeline system for water and sewage as well. Later, builders of classic Greece used pipelines of clay, hollowed stone, lead, and bronze.

900 B.C.

The Chinese were believed to have piped natural gas from gas seeps to use in brine evaporation. They are said to have had wells 1000 to 2000 ft deep.

600 B.C.

Gas wells were developed in Japan.

300 to 100 B.C.

A pipeline system not to be surpassed for 1900 years was constructed in Rome. The system handled 332,000,000 gal of water per day. Most of the pipe was made of lead; however, bronze was in use and the famed baths at Caracalla were fed with bronze pipes with faucets of solid silver.

1313 A.D.

First wrought iron pipe (used as cannons) was made in western Europe.

1583

Most water piping systems in western Europe employed hollow logs or lead pipe. This year the First London Bridge was completed and on it were two lead pipeline spans. Water was pumped through them by crude "horse powered" pumps.

1685

First underground iron pipeline was constructed in Paris. Joints of pipe were one meter long and joined by bolted flanges. Part of this system still carries water to the citizens of Paris!

1600 to 1800

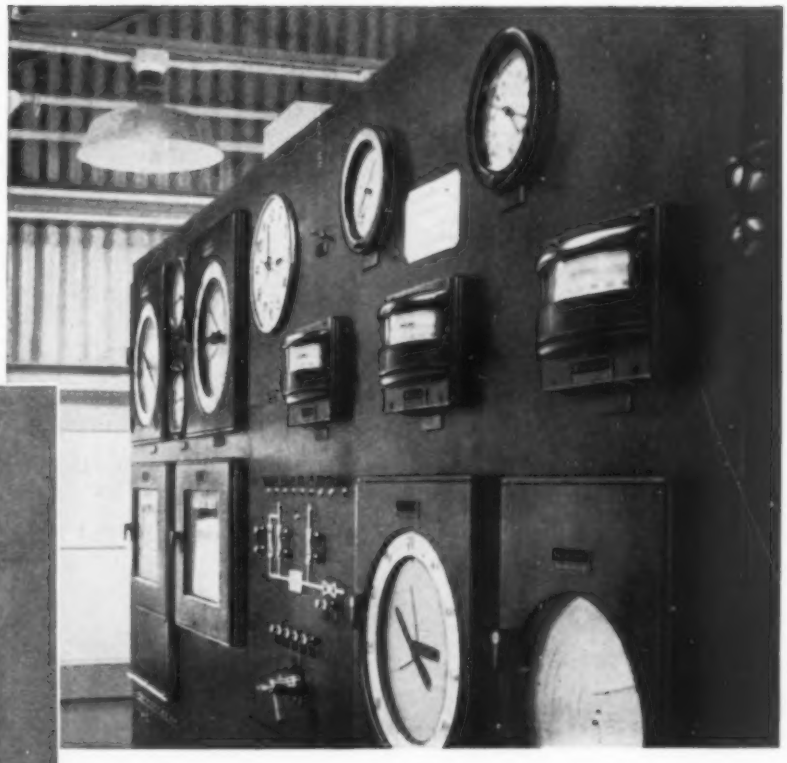
Most lines in America were made of hollow logs.

1775

George Washington and General Andrew Lewis purchased the first known gas property in the U. S. It was a burning spring on the banks of the Kanawha River, nine miles above the present city of Charleston, West Virginia. The tract was 123 acres in the heart of what was later to become one of the greatest gas producing areas.

CUT ALONG THIS LINE FOR YOUR PERSONAL REFERENCE FILE

This control panel at the Stanton satellite station permits fully automatic control—remote or local—including automatic alarm, startup, and shutdown.



At Gulf Interstate Gas Company's master control station, Nashville, Tenn., a section superintendent presses a button—shortly the satellite station at Stanton, 210 miles away, goes onstream, under full automatic control.

First satellite compressor station —completely automatic—

with HONEYWELL *instrumentation*

OPERATING completely unattended, Gulf Interstate Gas Company's satellite compressor station at Stanton, Ky., marks an important milestone in gas transmission.

The station has operated without a hitch since its completion early last year. Test results showed savings of 10 to 15% in operating costs . . . better control over line and delivery, especially during peak demand periods . . . dependability and safety, affirmed by FPC approval. This remarkable performance has encouraged Gulf Interstate to add four more satellite stations to its 1,160-mile system.

Much of the success of the satellite station is due to the fine degree of automatic control made possible by Honeywell instrumentation at the satellite and at the master control station at Nashville—210 miles distant. The satellite control system, designed for both local and remote automatic operation, includes Honeywell suction and discharge pressure controllers, and a completely automatic gas engine cooling tower control system.

Gulf Interstate's faith in Honeywell instrumentation has been borne out by the absolute reliability and accuracy so necessary in an unattended station.

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Honeywell
BROWN INSTRUMENTS
First in Controls

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1802

The first usage of natural gas in the western world appears to have been for lighting streets in Genoa, Italy.

1820

Extruded seamless lead pipe developed in England by Thomas Burr.

1821

This year marks the first useful consumption of natural gas in America. At Fredonia, New York, near Lake Erie, William Aaron Hart, a local gunsmith, drilled a 27-ft well on the banks of Canadaway Creek near a burning spring. Using lead pipe he ran the gas 25 ft to an inverted water filled vat, which he dubbed a "gasometer." He ran a ¾-in. lead line to one of the local inn's where it was used for illumination. This practice spread and Fredonia became the world's most lighted town. Its fame attracted sightseers and General Lafayette made a special trip from New York to see the amazing spectacle.

1838

Gas was discovered on a farm near Findlay, Ohio. It was piped to the house through wooden pipe and lighted off the end of a gun barrel.

1840

Gas was used for the first time in the U. S. for manufacturing salt, at Centerville, Pennsylvania.

1841

Gas was discovered and used to replace coal in West Virginia near George Washington's burning spring.

1859

Col. E. L. Drake drilled the first commercial oil well at Titusville, Pennsylvania.

1860

Natural gas development started in Kansas.

1862

The world's first crude line using centrifugal pumps was constructed in the booming oil fields of Pennsylvania by J. L. Hutchings, inventor of the rotary pump. He built the line of 2-in. cast-iron pipe with leaded sealed joints. The pump was successful in forcing oil over a hill to a refinery despite the many leaks at the joints. Strong-armed teamsters destroyed the line shortly after it went into operation.

1865

The first successful crude pipeline was constructed by Samuel Van Syckel. The Oil Transportation Association which he headed, built a screwed cast-iron line, 2 in. in diam and 32,000 ft long. Three steam-powered reciprocating pumps gave it a capacity of 1900 bbl per day. This same year natural gas was used for the first time in the manufacture of lamp black.

1872

Flare gas from the Titusville oil field was piped through 2-in. iron pipeline for a distance of five miles for industrial customers. Its capacity: 4,000,000 cu ft per day.

Pipeline scrapers or "pigs" were developed about this time. Then they were called "go-devils."

1879

"Big Benson Pipeline" constructed over the Alleghenies. The 6-in. line was 125 miles long, running from Bradford to Williamsport, Pennsylvania. It was cast-iron screw pipe.

1880

The first natural gas compressor station was put in operation by the Bradford Gas Company at Rixford, Pennsylvania. Its capacity was 5,000,000 cu ft per day with a discharge pressure of 60 psi.

1884

Gas was piped to Philadelphia—the city system had 335 miles of distribution lines handling 250,000,000 cu ft per day.

1887

R. D. Benson extended his crude line from Williamsport across the Ox-bow range to New York. Aside from crossing the rugged mountains, Benson's pipeliners laid 21,000 ft of line in the New York harbor. They laid it from barges, lashing a wooden barrel to every second joint. A thousand feet or so behind the laying crew, crews cut the lashings and lowered the line to the bottom. Because of trouble with shipping, the line was later replaced with heavier pipe and in 1889 it was lowered into a 4-ft ditch.

1891

The first high-pressure gas line was constructed by the Indiana Natural Gas & Oil Company. Two 8-in. wrought iron screwed lines were laid from Greenstown, Indiana, to Chicago. The working pressure: 525 psi.

The Dresser coupling was invented by Solomon R. Dresser.

1893

Capt. Jacob J. Vandergrift laid the first products line from Oil City to Wilkes Barre, Pennsylvania.

1901

The famous Spindletop oil field near Beaumont, Texas, was discovered. This was the first well drilled with rotary tools and it opened up the vast Texas oil and gas production, which had to be transported over long distances to reach the eastern and northern markets.

1906

Hepburn Act passed classifying interstate oil pipelines as common carriers.

1911

The welding of pipe joints by oxyacetylene was introduced to the gas industry on a 11-mile line of the Philadelphia and Suburban Gas Company. The orifice meter was invented by H. C. Cooper and J. G. Pew and used for the first time in West Virginia.

Weymouth Formula for computing gas flow through pipelines was introduced by Thomas R. Weymouth.

1912

Pipe screwing machine was developed for connecting pipe joints.

1913

Ditching machine developed. It resembled combination traction engine and ladder dredge, and could excavate trenches 6 to 20 ft deep and 1 to 5 ft wide.

1916

Underground storage of natural gas in depleted fields was introduced in the Zoar field, Concord, New York.

1918

Pipe bending machine was devised for 4 and 6-in. pipe. No heat was used.

1922

W. C. Heltzel started experiments that led to the first valid flow formula for crude and products.

1923

The first electrified trunkline stations were installed on crude line between Signal Hill and Los Angeles Harbor, California.

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Setting the pace for fast-moving spreads . . .

This ¾-yd. 22-B is trenching on a road approach on the Saskatchewan pipeline in Canada.

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22-B

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Bonus quality starts with highest grade steel which is flame-hardened to provide long-wearing gears and pinions.

Pipeline spreads fight enough obstacles — remote locations, tough terrain, bad weather — without having to put up with poor equipment. That's why contractors on fast-moving spreads like Bucyrus-Erie 22-B dragshovels — they know these rugged machines will set the pace and help them stay on schedule.

Bucyrus-Erie dragshovels are built for high-speed trenching. Speedy hoist and powerful digging strokes eat up maximum yardage in every shift. Responsive controls let the operator work at peak efficiency with little fatigue. Dipper design assures rapid filling and heaped loads, and clean fast dumps.

Most important, upkeep is low so you get maximum time on the job. There are few wearing parts and lubrication fittings are conveniently grouped and easy to get at. Dust shields protect the bearings of the track rollers from dirt and grit.

Your Bucyrus-Erie distributor will be glad to give you the complete details on the ¾-yd. 22-B dragshovel . . . and you'll be glad he did when you put it to work on your spreads.

291E56

BUCYRUS-ERIE COMPANY

SOUTH MILWAUKEE, WISCONSIN

1924

Tht first long distance, all-welded natural gas pipeline was constructed by Magnolia Gas Company of Dallas, Texas. It was 14, 16, and 18 in. in diam and ran 214 miles from Webster Parish field in Louisiana to Beaumont, Texas.

1925

Seamless steel pipe became available to the pipeline industry.

1927

First installation of motor-driven centrifugal pumps at the Coulter station of Illinois Pipeline Company.

1928

Electric arc welding process replaced oxyacetylene welding and seamless pipe in 40-ft lengths became available.

Aerial photographs were used to map the route of a pipeline from Yates field in West Texas to Port Arthur, Texas.

1930

The Federal Power Act empowered the FPC to regulate interstate gas industry.

This year marked the kick-off of the great expansion in products pipelines.

Coated electric welding rod was introduced.

First cathodic protection installation made for protection of pipelines.

1931

Natural Gas Pipe Line Company of America piped gas to Chicago from the Texas Panhandle; Panhandle Eastern Pipe Line Company's line was completed from Dumas, Texas, to Rockville, Indiana. All told, 7700 miles of gas transmission lines were constructed at a cost of $318 million.

1933

Stove-pipe method of construction, now universal practice, was tried for the first time in Texas; roll-welding was abandoned shortly afterward.

1934

Three-flame tip for oxyacetylene welding preheated metal and speeded operations.

1936

Dewatering method was used in laying a river crossing in Kansas.

1938

Traveling-type combination coating and wrapping machine became forerunners of today's equipment.

Natural Gas Act passed to confer on Federal Power Commission jurisdiction over interstate natural gas rates.

1941

Pressure welding was used experimentally on a short line in Arizona. The practice has never become popular.

Consent Decree limits dividends by pipeline companies to shipper owners to 7 percent of pipeline valuation.

1942

Coating and wrapping machine was improved to double-coat and double-wrap pipe in a single operation.

Beginning of automation in pipeline compressor stations.

American Standards Code for Pressure Piping was adopted.

1943

Machine for cold-bending large diameter pipe was first used on the 1340-mile "Big Inch" war emergency pipeline, which was completed at a cost of $78 million this year.

Angle-type compressors introduced on natural gas pipelines.

1945

Internal lineup clamp was introduced and proved practical as an aid in pipeline construction.

1946

X-ray inspection of welds, now widely practiced, was introduced into the pipeline industry in California.

Submerged electric arc welding process was used on 30-in. pipeline in California.

1947

Texas Eastern Transmission Company purchased the "Big Inch" and "Little Big Inch" pipelines for $143 million from the federal government and introduced for the first time electrically-driven centrifugal compressors to handle large volumes of gas.

1948

Hydraulic bending machine was used successfully in making smooth bends on large-diameter, thin-wall pipe.

1949

The first gas turbine to drive centrifugal compressors for transmission of natural gas was installed on El Paso Natural's line.

The first microwave communication system was introduced by Keystone Pipe Line Company.

Pipe was double-jointed by submerged arc welding process in central yard.

1950

Pipe was double-jointed on right-of-way by submerged arc welding process.

First offshore, two-phase gas line was laid in the Gulf of Mexico, off the Louisiana Coast by Marine Gathering Company.

1952

ASA-B31.1-Section 8, Code for Transmission Piping, was approved by American Standards Association, which is a revision of the 1942 code.

1954

Improved asphalt coating permits pre-coated pipe to withstand hydraulic bending machine. Cooling tower was developed for over-the-ditch construction. Directional surveys were made on under-water pipelines. Automatic welding machine was used on aluminum pipelines. Helicopters were used on marsh land surveys, and pipe was coated internally with epoxy resin.

1955

Portable rock crusher was developed for right-of-way operations. Hot tap was made under 22 ft of water in the open Gulf. Ultrasonics used in offshore surveying.

1956

First fully automatic main line compressor station was constructed on Gulf Interstate Pipe Line Company's system.

Two lines for carrying solids were completed—for coal and gilsonite. Both products were pumped in the form of a slurry.

Machine developed to provide material from spoil bank for padding ditch in rocky areas, eliminating hauling of rock-free soil for this purpose.

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Institute of Gas Technology Home Study Course.

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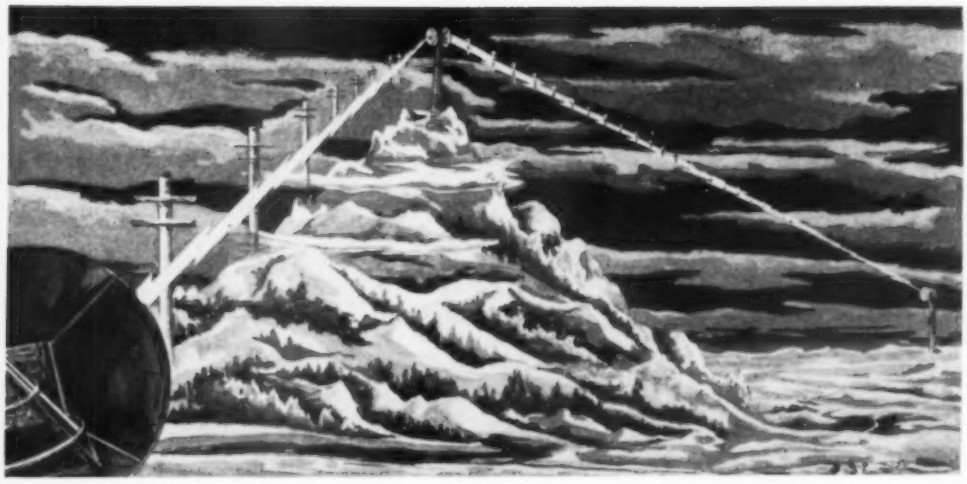


microwave Completes Round-the-Clock Communications for Charleston Group

Provides for two telephone, one radio, and one testing conversation simultaneously — 30 more channels can be added with same basic equipment

RECENTLY the Charleston Group* of Columbia System began operating a microwave communications system in Virginia and Maryland. Long without its own communication facilities from Bickers compressor station to Falls Church, Virginia, this microwave system completes the round-the-clock communications network of the Charleston Group. Now an employee in the Charleston headquarters can pick up the phone and call south along the 20-in. to ASC headquarters in Falls Church. The other side of the clock, or the telephone system from Charleston to Falls Church along the "Toughest Inch," has been in operation since 1952.

The new microwave system starts with a directional antenna at Bickers compressor station, near Standardsville, Virginia. Here the signal is beamed to the top of Fork Mountain, 14 miles away, where a repeater station picks it up, amplifies it, and sends it on to Dranesville measuring station just outside of Falls Church, Virginia.

Fork Mountain was chosen for the repeater station location to permit unobstructed transmission between the mountain and Dranesville, a distance of 70 miles. One of the longest station-to-station hops in the United States, it is possible through the drop in elevation from 3852 ft on Fork Mountain to 361 ft at Dranesville.

Fork Mountain is in Madison County, Virginia, 30 miles southeast of Charlottesville. It is on the edge of Shenandoah National Park, near former President Herbert Hoover's old fishing camp in the headwaters of the Rapidan River.

"The secret of good communications is having separate trunk and party line systems," explains Delbert York, superintendent of communications. "Our microwave provides a new trunk line from Bickers to Falls Church. The trunk continues to Lexington, Virginia, through carrier circuits operating over our own telephone line. This was installed the first of last year but was only put into use when the microwave was ready.

"The Lexington telephone operator can continue this trunk service by patching the circuits into other telephone facilities all the way to Charleston." This gives us the separate trunk and party lines we need for good communications."

The microwave system's trunk capacity allows two telephone, one radio, and one testing conversation to go on at the same time. Thirty more channels can be added to the network with the same basic Westinghouse equipment.

Why did we install microwave instead of conventional telephone lines?

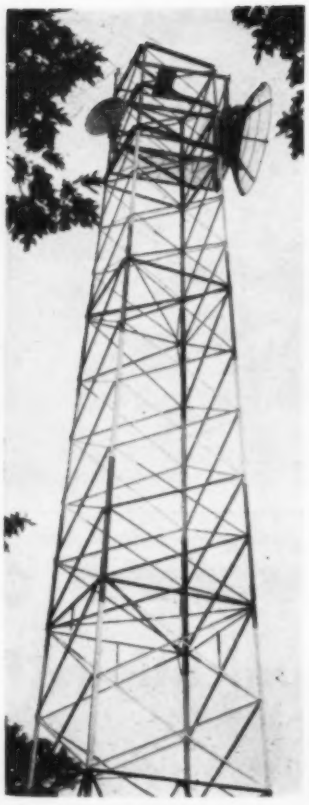
"For several reasons," answers Larry David, chief ASC radio technician who supervised the microwave installation. "The cost and expense of getting telephone wire right-of-way through large Shenandoah Valley plantations would have been higher than the $34,000 this system is costing.

"Also," he continued, "microwave operates with high efficiency during ice, snow, rain or wind storms — a time of greatest need for gas company communications and a time when wire line systems are subject to their most trouble."

The microwave system also is connected to the Fork Mountain VHF base radio station so that microwave circuits can be used for calling mobile units in the Fork Mountain area.

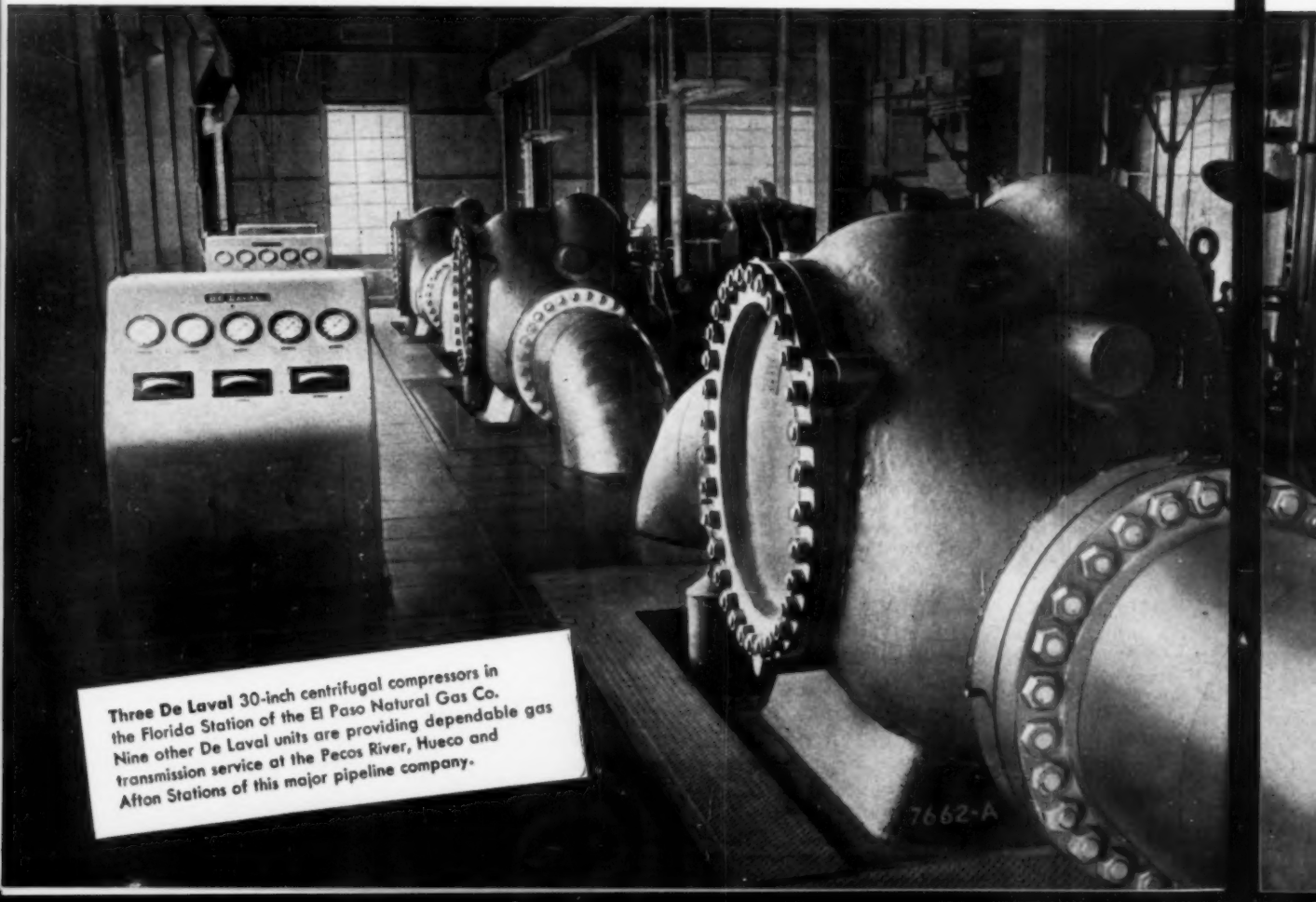
Like other construction projects in the Group, this project had its share of

*The Charleston Group consists of Amere Gas Utilities Company, Atlantic Seaboard Corporation, Big Marsh Oil Company, Central Kentucky Natural Gas Company, United Fuel Gas Company, and Virginia Gas Distribution Corporation.



Microwave signals take to the air from directional antenna at Bickers compressor station, beamed to Fork Mountain, 14 miles away (above). **Atop Fork Mountain** is a repeater station. This location provides unobstructed transmission to Dranesville, one of longest station-to-station hops in U. S. (right). **The Dranesville terminal,** 84 miles from Bickers (far right).

delays. Most of them were caused by equipment delivery delays. Company men Roger Falls and Raymond Weeks, both telephone men; Byron Jordan, telephone foreman; Claude Keith, radio technician, and Larry David be-



Three De Laval 30-inch centrifugal compressors in the Florida Station of the El Paso Natural Gas Co. Nine other De Laval units are providing dependable gas transmission service at the Pecos River, Hueco and Afton Stations of this major pipeline company.

gan installing some equipment last spring.

Equipment kept arriving until November 15 when the last piece was installed. Company men and engineers tested equipment as it was installed.

Russell Clapper, Jr., will maintain the Dranesville microwave installation. Claude Keith will maintain the installations at Bickers and Fork Mountain. Both men attended microwave school conducted by Westinghouse for their customers' technicians.

What about future use of the microwave system?

"With the 30 additional channels waiting to be used," Delbert York answers, "we can put such things as telemetering, teletype, fascimile, and supervisory control on the system. For example, we can use it to transmit telemetering and control information from Bickers to Dranesville."

Although not yet tested by years of use, the new system is expected to provide faster, more efficient communications for a company that depends on communications to operate.

Acknowledgment

This article was adapted from one published in *The Pipeline*, company magazine of the Charleston Group. For this permission, and loan of the illustrations, grateful acknowledgment is made.

New form of communications poses some problems for Delbert York, communications superintendent, and Claude Keith, radio technician (above). **Communications men** and microwave engineers study signal generator and microwave station (above right). Claude Keith, who services microwave stations, and Larry David, ASC chief radio technician, study the installation (right).

* * *

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Pipeline Personals

▸ **Roy J. Tibbets,** chairman of the board of directors, Sinclair Pipe Line Company, Independence, Kansas, has retired, following 42 years of service to the company and its predecessor organizations.

Earl W. Unruh, formerly vice president-operations of Sinclair Pipe Line has

R. J. Tibbets

E. W. Unruh

been elected president and chairman of the executive committee to succeed **William H. Morris** in both posts. Morris was recently elected vice president of Sinclair Oil Corporation of which the pipeline company is a subsidiary.

▸ **L. E. Davis** has been appointed general superintendent of operations and construction and **M. E. McGowan** as chief engineer for the Marine Gathering Company.

▸ **Robert A. Bainter,** former assistant superintendent, has been appointed superintendent of The Wyoming Nebraska Pipe Line Company. Other appointments announced by the company include **Earl R. Ferguson,** former Sidney terminal supervisor, to the post of assistant pipeline superintendent, and **Robert E. Fleenor,** former terminal operator, to Sidney terminal supervisor.

▸ **Carl H. Gompf,** manager of pipelines for the Ohio Oil Company, has retired after more than 46 years with the com-

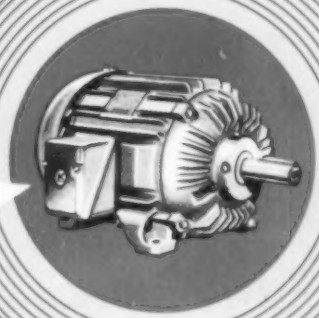
J. H. Rice

R. M. Slough

pany. He has been pipeline manager since 1953. Succeeding him is **J. H. Rice,** assistant manager. **Ralph M. Slough,** manager of pipeline electrical and communications department, becomes assistant manager.

▸ **Earl C. Norris** has been promoted to the position of general superintendent of field operations for Houston Contracting Company. He has been with Houston Contracting for 20 years, and during the past 17 years has been spread superintendent.

▸ **Ernest F. Semrad** has been appointed assistant chief engineer of the Michigan Wisconsin Pipe Line Company and of American Louisiana Pipe Line Company. Both pipe line firms are subsidiaries of American Natural Gas Company. **James J. Trebilcott** was named assistant manager of operations of the Michigan Wisconsin Pipe Line Company.



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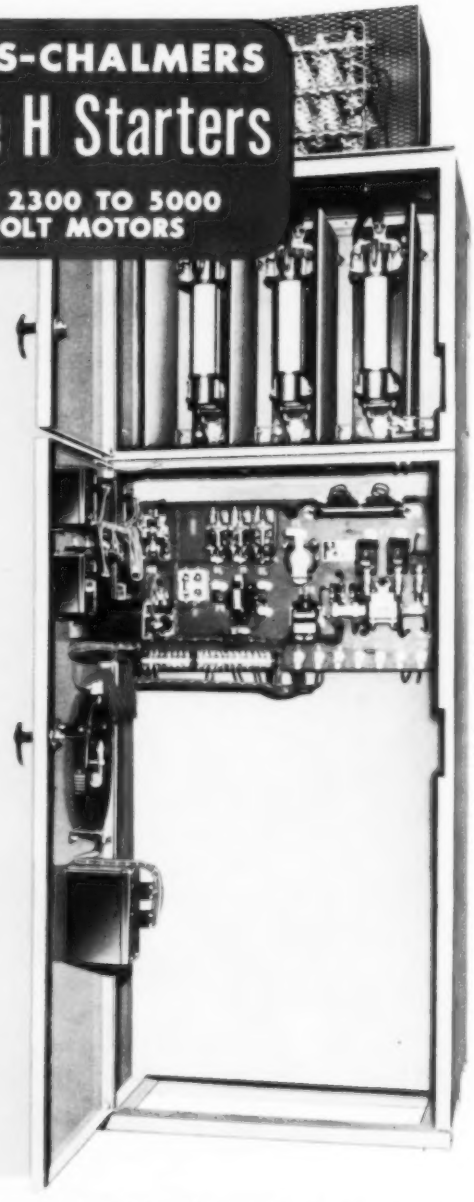

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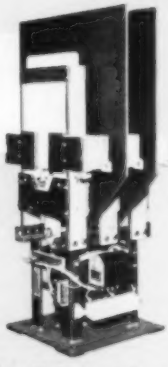

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The giant trench prepared for Texas Eastern's pipelines, which will import Mexican gas, is shown just short of the Rio Grande. Well points were sunk to extract water from the soil and make digging easier. The bluff in the background is on the Mexican side of the river.

P 623.

They Moved a River, Dug a Ditch as Wide as the Panama Canal . . .

And these were only two of many problems faced in constructing Texas Eastern's new line across the Rio Grande to import Mexican gas

Frank H. Love
Editor

MOVING a river and digging a ditch nearly as wide as the Panama Canal are just two of the many problems confronting engineers and workers who are constructing a new natural gas pipeline across the Rio Grande for Texas Eastern Transmission Corporation of Shreveport, Louisiana.

The river crossing is part of a major expansion program authorized by the Federal Power Commission during 1956 that will increase the capacity of Texas Eastern's system by some 20 percent or approximately 250,000,000 cu ft daily.

Texas Eastern's new pipeline construction will connect its system with facilities of Petroleos Mexicanos (Pemex), the decentralized oil and gas agency of the Mexican Government. When completed, the line will allow Texas Eastern to become the first major importer of natural gas from Mexico.

Why is it necessary to move a river and dig a ditch of such size just to get two 20-in. pipelines across the Rio Grande?

Anyone who is familiar with the Rio Grande and its capricious actions knows the reason, but for those who are not acquainted with the river that serves as the international boundary between the United States and Mexico, the problem is this. The Rio Grande has its beginning in San Juan County, high in the Colorado Rockies. Some 1800 miles to the southeast it ends in the Gulf of Mexico. From a small mountain creek it becomes a roaring stream as it passes through the mountains and down onto the plains of the Southwest. There it becomes a sluggish river lazily rolling across the desert and plains areas into the Gulf. Sometimes it is just a small, dirty-looking, ambling stream, almost narrow enough for a boy to jump across. At other times it becomes a roaring, surging mass of water, almost to wide to see across.

The "Sleepy Rio Grande" also has other tricks up its sleeve. Its banks and river bed are seldom found in the same place two consecutive years. When it is a lazy small stream it gently deposits silt along its bed, but when it becomes a raging torrent then the swirling waters quickly eat away the stream bed and gouge out a new one.

To lay a pipeline across this river, it is necessary that the pipe be placed deep enough in the ground so that the gouging or scouring action of the water will not eat enough of the river bed away to expose the pipe. Also the pipe must begin sloping downward to go under the river at a point much farther back from the banks of the river than any known point of bank change that has been noted.

A Three-Stage Operation

Crossing of the Rio Grande will be done in three stages. Briefly, contractors will dig a ditch for the pipe on the United States side of the river. They will then lay two 20-in. strings of pipe 50 ft apart. The path of the river chan-

Joining pipe sections northeast of McAllen. Welder's helper at right holds a large sheet of wood to protect welder's arc from the extremely high winds, not unusual in the area.

nel will then be diverted over the two 20-in. lines by using a man-made canal. A ditch will be dug across the normal river bed and pipe will be placed in the ditch. The pipe will be covered and the river returned to its normal course. Construction workers will then dig the ditch for the pipe on the Mexican side of the river and the job will be complete.

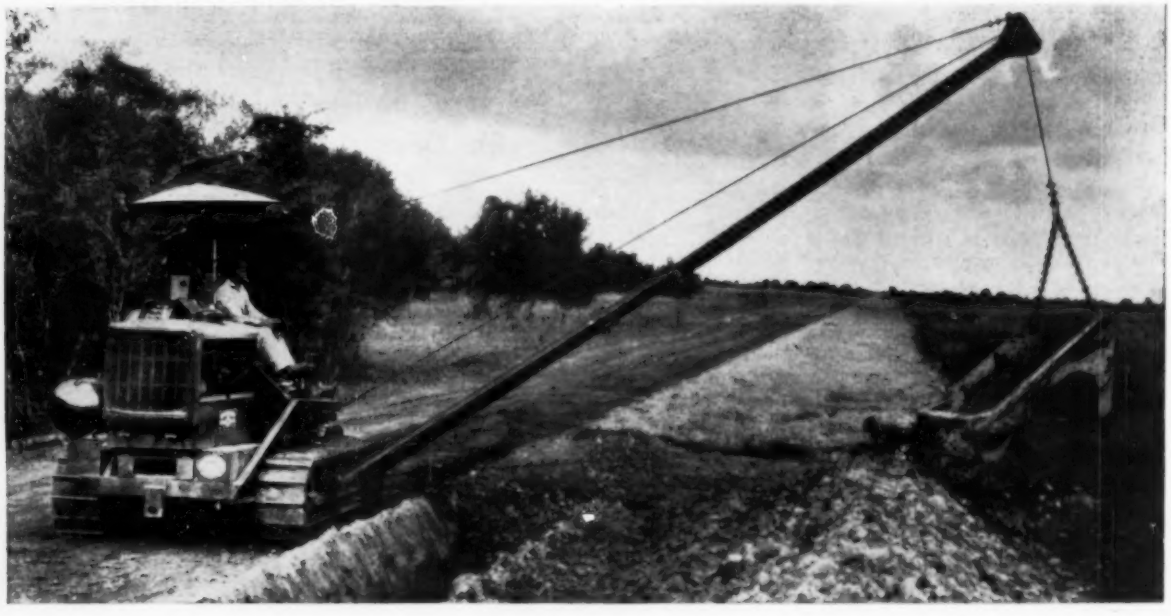
To start the river crossing it was first necessary to obtain a right-of-way 1600 ft wide to accommodate the spoil from the large scale digging operations planned. At the same time, negotiations were being completed with a number of government agencies for permission to cross the river including the U. S. State Department, the Department of the Interior, the Federal Power Commission, the International Boundary Commission, the Immigration Service, and others. Special permission had to be obtained from the International Boundary Commission for the Rio Grande project because the pipeline was planned to cross the river and the international boundary at an unauthorized point of crossing.

Dirt moving equipment was brought to the scene and the gigantic task of cutting what has been termed by some men on the job a "new Panama Canal" was started. To start under the river at a point far enough back to be safe from any erratic bank changes the river might possibly make, it was necessary to begin digging some 1100 ft back from the centerline of the river on the United States side. Later, when digging operations are started on the Mexican side of the river, crews will begin their digging at a point some 900 ft back from the centerline of the river.

Pipe 25-ft Deep

At this time much of the ditching operations on the United States side has been completed. The hole in the ground is almost as wide as the Panama Canal and is more than 25 ft deep. When crews are ready to lay the pipe under the river bed, the ditch will be at least 10 ft below any known scour depth of the river and well clear of any such action on either side of its banks.

The pipe that will be used is ½-in. wall pipe. It will be coated with alternate layers of hot coal-tar enamel, glass fiber wrap, and asbestos pipeline felt. In addition the pipe will be encased in a heavy concrete jacket. When the coating and wrapping processes are completed, the pipe will weigh approximately 245 lb per ft.



WORKING ON THE HEELS OF THE LOWER-IN CREW a one-man-operated Cleveland 190 helped to keep this United Gas pipeline job moving along, leaving no open trench at the end of any day's work. A report from Fowler-Tatom Pipeline Contractors states, "The Cleveland 190 backfilled trench almost as fast as a man can walk." Where trenches were water-filled the 190 tied down pipe then doubled back to complete the fill and finished it off with a neat clean-up job. Much of the 16-mile line from the Chocolate Bayou field to the main line near Webster, Texas, cuts through rice-growing farmlands, so the 190 had to pull down big heavy spoil banks of wet sticky gumbo much of the way.

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There will be large safety control valves on both sides of each of the two lines crossing the river. In addition, there will be a check valve on the United States side of the river.

While engaged in construction work on the Mexican side of the Rio Grande, workers will erect a solid fence around the construction area. The only entrance will be from across the Rio Grande on the United States side. Constant check will be maintained by immigration authorities and the agricultural department to see that no violations of border crossings are made.

Actually, the Rio Grande crossing is more of a dry-land operation than it is a river crossing. Engineers found that dry-land methods of laying pipe would be more economical and efficient and would provide greater protection for the pipe than the usual river crossing methods.

To Divert River's Course

Dry-land operations are indicated by the fact that engineers will divert the course of the Rio Grande and use dry-land digging equipment to cut the ditch across the river bed instead of using the usual dredging procedures. To divert the river, crews will construct large earthen dams across the stream bed. Draglines, bulldozers, and diggers will swing into action and carve out a new channel for the river to flow through on U. S. territory.

Since the water table in that area is at such a shallow depth (10 ft or less in some spots) dewatering equipment has become standard for the pipeliners. Well points are sunk into the ground at close intervals and a system of piping connected to pumps is used to pump away the water. When the river bed has been dried out, dry-land ditching machines will swing into action and carve out the trench for the pipe just as if it were a normal dry-land operation.

Connect with New Line

When completed, the river crossings will tie in with a new 30-in. pipeline Texas Eastern is constructing from its Vidor compressor station, near Beaumont, Texas, to the Mexican Border just south of McAllen, Texas. The new line will carry the natural gas imported from Mexico and will also carry gas gathered from many producing areas in South Texas.

At this time of the year it would be expected that rain, cold weather, and mud would hamper pipeline and river crossing crews, but on Texas Eastern's new 30-in. line connecting to the Pemex facilities in Mexico the principal item retarding work is wind.

The route of the line skirts along the Texas Gulf Coast as it heads for Beaumont. The cold winds blowing down from the northwest and the warm winds coming in off of the Gulf of Mexico cause severe, turbulent wind conditions. Pipeline construction crews have lost several days of valuable time due to high winds.

There are many creeks, irrigation ditches, bayous, and farm roads to cross, and to make matters more difficult, the pipeline is moving through a rich citrus fruit growing area. To lay the pipe, construction crews must remove the fruit bearing trees and plants, remove the topsoil, dig the trench, lay the pipe, fill the ditch, and then replace the topsoil. Then there are the ever-present rattlesnakes, almost as numerous as cactus plants.

In addition to the many citrus groves, the pipeline crosses some of the largest cattle ranches in the world including the King and Kennedy ranches. On the vast expanses covered by these ranches, there are few roads for use by trucks hauling equipment for the pipeline. In addition, workers are forbidden to carry firearms or matches while working on the ranch property. This rule also applies when the pipeline spread is crossing one of the many government wildlife preserves in that area.

Regardless of obstacles, the work of constructing the pipeline goes steadily

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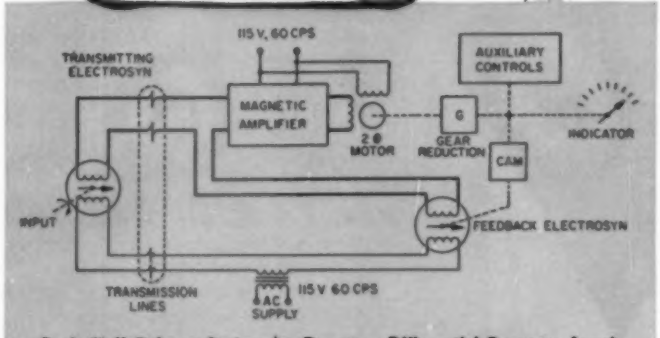

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See ElectroSyn System in operation at PIEA-PESA Show, Booths 64 - 67, Shamrock Hotel, Houston - April 16 - 18

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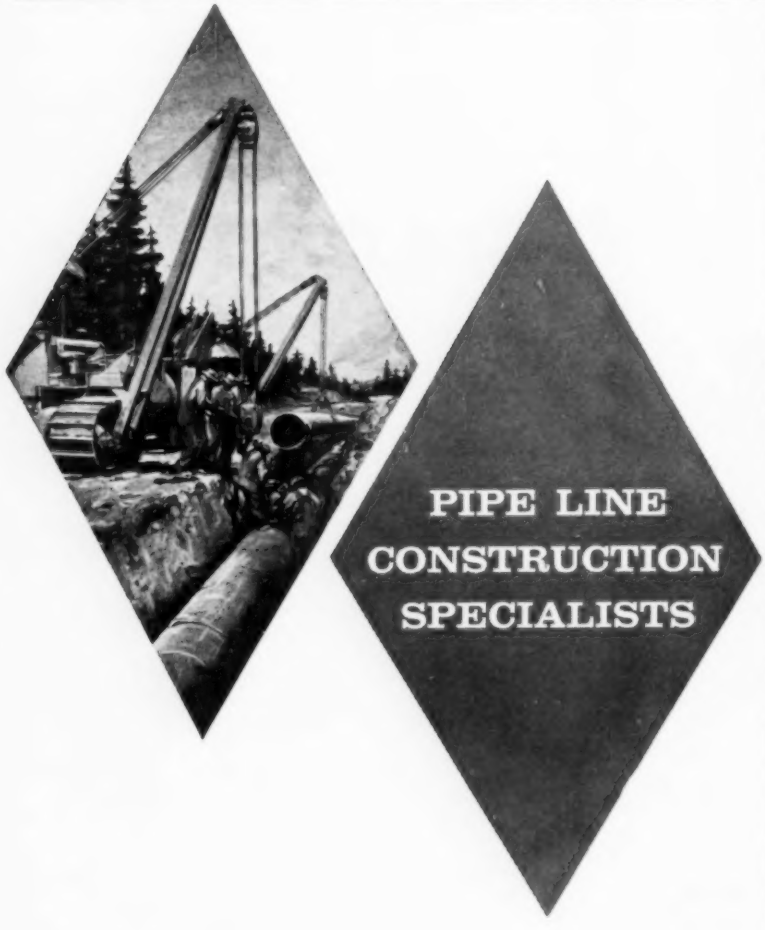
onward at the rate of about four miles per day. The line will soon be completed and will begin transporting natural gas from fields in northern Mexico to markets in the northeastern part of the United States.

The project had its beginning back in December 1955, when Texas Eastern filed an application with the FPC seeking authorization to import natural gas from Mexico and to construct the needed facilities to transport the gas.

The previous year, Texas Eastern had filed an application asking for authorization to remove a large segment of the Little Big Inch pipeline extending from Beaumont, Texas, to Moundsville, West Virginia, from natural gas service and to construct substitute facilities that would replace the removed capacity of the company's system. Plans were to reconvert the removed portion of the line back to its original purpose of carrying petroleum products.

In April 1956, the two applications were consolidated into one expansion and diversification program to expedite additional hearings deemed necessary by court action. On October 9, 1956, the FPC granted authorization for the expansion of facilities that would include the importation of substantial quantities of natural gas from Mexico. Hearings are still in progress on the reconversion of the Little Big Inch line.



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When the expansion project is completed, Texas Eastern's system will have a capacity of approximately 1,635,000 Mcf of natural gas daily and the company will be operating more than 5700 miles of pipelines from the Southwest to the East Coast. The Mexican gas will be available at the rate of some 115,000,000 cu ft per day with the contract providing for this volume to be increased up to 200,000,000 cu ft per day as additional reserves in the fields covered by the contracts are developed.

The gas will be purchased from Pemex's new natural gasoline absorption plant across the international border at Reynosa, Mexico. The plant will process the natural gas as it comes from the three fields covered by the purchase contract with Texas Eastern, the Lomitas, Brazil, and the Trevino fields, all in northeastern Mexico.

Texas Eastern is constructing its facilities to the international border with Pemex doing the same thing on the other side of the Rio Grande. The cost of the river crossing will be shared by Texas Eastern and Pemex.

Facilities authorized for the expansion program and which are now under construction include approximately 422 miles of 30-in. pipeline extending from the international border near McAllen, Texas, to Texas Eastern's Vidor compressor station near Beaumont; approximately 45 miles of 24-in. pipe connecting Texas Eastern's existing line near Provident City, Texas, to the new line; pipeline loops totaling about 77 miles at various locations along the company's existing 30-in. system; approximately 147 miles of supply and sales laterals; new and additional compression facilities totaling 32,250 hp, and approximately 20 sales measuring and regulating stations. The expansion project is expected to be completed during the fall of 1957.

By the end of January 1957, construction crews had completed a 71.2-mile stretch of the 30-in. pipeline between Lavaca Bay and the Nueces River and Bay along the Texas Gulf Coast and north of the Mexican Border. They also completed laying some 70 miles of a 134.3-mile stretch of the 30-in. pipeline between the Nueces River and Bay and the Rio Grande. Construction crews are working both ends of this segment of the pipeline project.

In addition to the crossing at the Rio Grande, there will be 15 other crossings of rivers and bays to be made. These crossings will be made according to usual river crossing procedures.

The cost of expanding the system and constructing the new line to Mexico is approximately $82,700,000.

★ ★ ★

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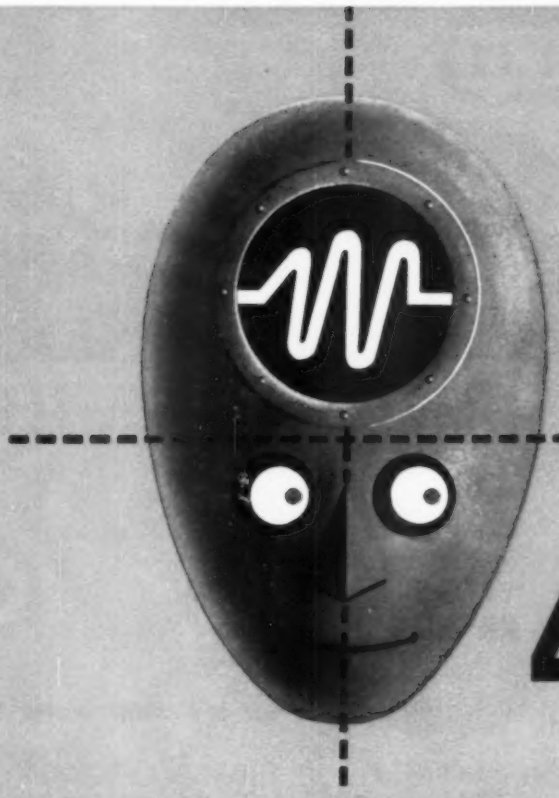


THE E-I-M

FUTRONIC

VALVE CONTROL

masterminds

48,000

barrels a day,

For complete details of the FUTRONIC valve control write

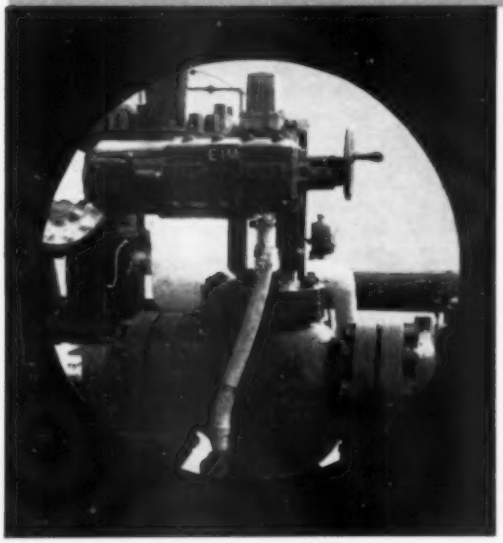
E-I-M

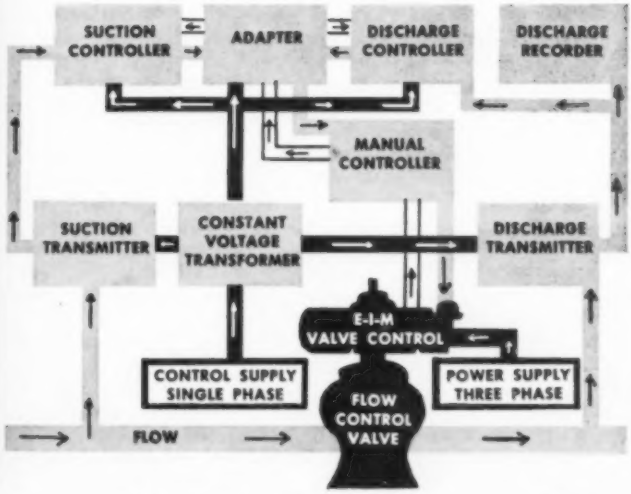
COMPANY, INCORPORATED
1340 Old Spanish Trail
Houston 25, Texas

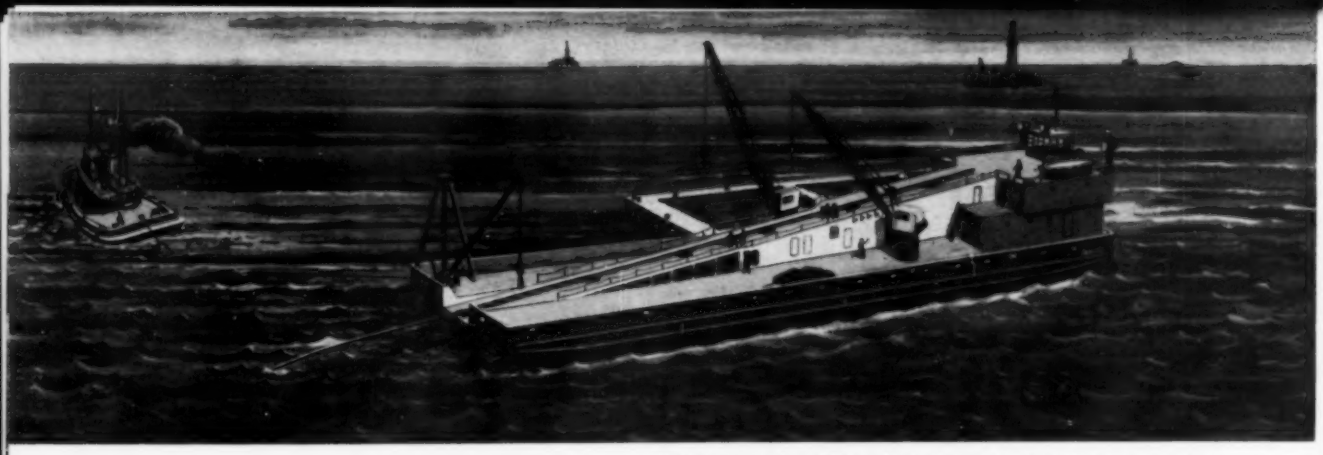
The FUTRONIC regulates this crude oil output at a fully automatic, completely unattended pumping station in Southern Oklahoma.

The FUTRONIC valve control system, is particularly valuable in meeting pipe line compressor station, pipe line pumping station and metering station requirements.

Units are adaptable for readout, cascading, computer and similar systems. Transmission distances of great length are permissible and it is possible to tie in with leased wire, micro-wave and other metering systems.







Artists conception of the "Magic" at work. Note the two cranes which can feed pipe onto the ramp from barges on either side. The stiff leg crane aft can be used to support pipe and to lower it over the side.

P 615.372

"magic" For Marine Lines

Newest sea-going pipe laying barge will lay deep water lines

As the oil industry fans out into the sea, more and more strange looking craft slip down the launchways to form a supporting "navy." Their design is functional — beauty and sleekness of line are secondary.

Latest to join the oil industry's navy is Commonwealth Oil Company's marine pipelaying barge, the "Magic." It's an ultra-modern, $750,000 craft, and to marine pipeliners she's the prettiest thing afloat. It is the first vessel specifically designed and built for the tough job of laying pipelines beneath the tricky, sometimes dangerous water of the Gulf of Mexico, G. Burton Liese, Commonwealth president, said.

Specifications for the "Magic" were drawn by Robert C. Ledford, vice president of Marine Gathering Company, a wholly-owned subsidiary of Commonwealth, which will operate the barge. Ledford is one of the nation's leading authorities on marine pipelines.

L. E. Davis is superintendent of construction and operations for Marine Gathering and M. L. McGowan is chief engineer.

Design was executed by Christensen and Graham, marine architects of Pasadena, near Houston. The barge was constructed at the Marine Fabricating and Engineering Company shipyard in Greens Bayou, and industrial suburb of Houston.

The barge will begin operations immediately after the commissioning.

Contracts are assured for sufficient work to keep the vessel busy for an extensive period, and details of its first pipelaying operations will be announced in the near future, Liese said.

With 64 oil and gas fields, representing estimated reserves of 1.5 billion bbl of oil and 10 trillion cu ft of gas, already discovered, several lines have been strung along the Gulf floor. Production in 1956 was at the rate of 92,550 bbl of oil daily and 390 million cu ft of gas per day.

Commonwealth itself, through Marine Gathering Company, owns lines connecting the Rollover field off Vermillion Parish, Louisiana, to its dehydration plant on the mainland, from which it delivers gas it has gathered offshore to several transmission companies.

The "Magic," which is 260 ft long and 50 ft wide, incorporates the highest standards of seaworthiness, crew safety and work efficiency in design and construction, which are recognized officially by the United States Coast Guard, Liese said.

With thousands of men engaged in work in the Gulf, the Coast Guard has begun taking a closer look at offshore operations in general during the past year.

Commonwealth's barge, designed and constructed to American Bureau of Shipping standards, has received Coast Guard approval, the first such approval known to have been given to an offshore pipelaying vessel.

Ledford, who supervised laying of the first underwater pipeline in the Gulf for Marine Gathering Company in 1950, and bumped head-on into some of the toughest technical problems ever encountered in the colorful history of pipelining, believes the "Magic" is equipped to cope effectively with any situation that may arise.

Equipment design and planning of pipelaying techniques were influenced by Ledford's wide experience in offshore pipeline construction.

A tug will tow the "Magic" to each project, either at the shore end of the pipeline or at the producing platform offshore.

Mounted on the barge is a ramp running the full length of the vessel, on which all of the various joint welding and waterproofing operations take place. On each side of the ramp is a 35-ton crane for lifting pipe sections into place. Under the ramp are the equipment rooms.

At the extreme forward end of the barge, two decks of crew quarters topped by the captain's bridge, comprise the superstructure.

From the bridge, the "Magic's" captain will pull the vessel along in a "bootstrap" operation by means of anchors at each of the four corners of the barge and special winches to operate the anchor cables. A tug will drop the barge anchors well in front of and behind the pipelaying vessel. Then by pulling in on the forward anchors and

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letting out on the aft ones, the captain will move the barge forward. The tug will operate around the barge continually, repositioning the anchors. With two anchors at each corner and only one being moved at a time, the barge will be held firmly in position at all times.

A ballasting system in the 13½-ft high hull will permit the barge to draw as little as four feet of water near the shore and as much as eight feet in deep water, where the additional draft will contribute to stability. The hull is cross-hatched into small watertight compartments to increase its seaworthiness. Cathodic protection is used to elminate corrosion of the hull.

At the nearest point ashore, a radio equipped house trailer, fitted as a personnel and material procurement office, will be stationed.

Normal complement for the "Magic" will be 46 men, headed up by Pipe Superintendent Albert Cohen and an assistant superintendent. Captain W. C. (Bill) Hanson, a first mate and five able bodied seamen will operate the barge. Two shifts of pipeline workers will each include a ramp foreman, six welders, six helpers, a crane operator, two "swampers" or "roughnecks," and an X-ray technician to check all welded joints. By having two such crews, the barge can be operated on a 24-hour basis. A chef and two galley stewards make up the rest of the complement.

Housed under the ramp will be an air conditioned X-ray developing room, tool room, shop, main switchboard and electrical equipment. Included in this equipment are two 200-kw diesel-driven main generators, an auxiliary emergency generator, welding machines, air compressors, air conditioning equipment and fresh and sanitary water pumps.

In addition to the crew's four-man staterooms, visitors' rooms, washrooms, kitchen and dining hall, the living quarters will also include automatic laundry equipment, a recreation hall and other facilities for the comfort of the men. A sickbay and office will also be housed in the superstructure.

The barge is capable of laying 2000 ft of large diameter pipe or 5000 ft of small diameter pipe during each 24-hour period, taking bad weather and routine mechanical shut downs into account.

In actual operations, the barge moves 40 ft, the length of one section of pipe, at a time. From a smaller supply barge tied alongside the "Magic," the 95-ft boom of one of the giant cranes lifts a section of pipe into place. Except for a small length at each end left open for welding joints, the pipe comes already coated with corrosion resisting materials and covered with a heavy sheath of mesh-reinforced concrete used both to weight down the pipe and to protect it from corrosion and marine life.

That portion of the pipeline which is already completed trails off the stern of the barge into the water. As the barge moves forward, the pipe is lowered to the bottom or into a ditch already dredged along the ocean floor.

The new section is hoisted into place at the end of the pipeline at the top of the ramp. The first work station is for line-up and stringer bead. Next comes the hot pass.

Instead of sliding down the ramp, the pipe actually rides smoothly on pairs of automobile tires, which are mounted on the ramp in such a way that they can turn freely.

As 40-ft sections of pipe are successively swung into place at the top of the incline, work is going on simultaneously at all five stations along the ramp.

Two welders man the third position on the ramp, one to apply "filler" weld and the other to put on "cap" weld.

At the fourth station, an X-ray photograph is taken of the joint to make certain that it meets the rigid submarine requirements. Then, while the joint is being wrapped with polyvinyl tape for corrosion and water resistance, the X-ray film is rushed to the laboratory under the ramp for developing. Final approval of the joint is given by an inspector assigned by the owner of the pipeline and is based on an examination of the X-ray.

The joint then moves to the fifth station, where it is covered wtih a flexible form which is filled with concrete.

When the barge moves once more, the finished section slides gently into the water. The "Magic" will be part of a unique seagoing fleet, which will include a crew boat for transporting personnel to and from the barge, an electronically-directed buoy boat for dropping markers setting the line for the pipe, a tug to bring loaded pipe barges and remove empty ones, the pipe barges, and a second tug to reposition the anchors constantly as the barge moves forward.

"In setting out their design requirements, Ledford and his entire staff have included all the features for which they have seen a need on other projects and have eliminated the bottlenecks and undesirable features of other pipe laying equipment," Liese said.

"As a result, we have an efficient pipelaying vessel, capable of working as far as 50 miles from land, and based on some of the best practical and theoretical engineering experience available in the field of offshore transmission lines." ★ ★ ★

"Laid 70,000 Feet of Electric Cable at McConnell Air Base"

"We dug 70,000 feet of ditch with our Vermeer 524T Pow-R-Ditcher putting in electric cable at the McConnell Air Base. Total repair cost to date is less than $75.00. This machine will surprise you! It is rugged . . . does a fine digging job . . . and costs so much less than other ditchers and trenchers."

James K. Steele and
Supt. Fred Atterbary
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VERMEER 524T POW-R-DITCHER DIGS 8"-24" WIDE & 6' DEEP

An ideal machine for contractors, municipalities, utility companies, ets. The 524T is self-propelled, one man operated. Digs at speeds of 1' to 15' per minute.

FOR FOUNDATION FOOTINGS, GAS, WATER & SEWAGE LINES

Learn about the 524T Pow-R-Ditcher . . . the low-cost ditcher that digs for less ! Highly maneuverable. 2-way side conveyor. Smaller models also available . . . write for complete information.

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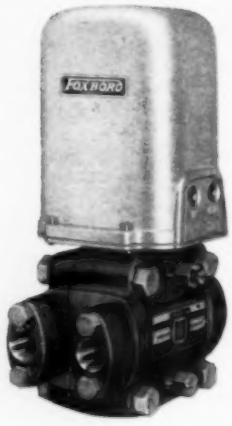
GET THE BEST SOLUTION TO EVERY FLOW

. . . with Foxboro Instrumentation

Differential Pressure Cell Transmitters

Complete line includes air operated and electric-operated d/p Cell Transmitters covering ranges from 0-20" to 0-800" of water; working pressures up to 1500 psi.



Type 13A d/p Cell Transmitter

- Positive Overrange Protection—up to full 1500 lb. rating
- Fully Adjustable Ranges—0-20" to 0-80" and 0-50" to 0-250" water
- Automatic Internal Damping — fast, stable measurement
- Simplicity—easiest, lowest-cost installation, lowest maintenance

Mercury Type Meters

Complete line includes mercury types covering ranges from 2 to 400" of water; working pressures up to 5000 psi.

Type 28 Mercury Meter

- Permanent Full-Scale Meter Accuracy — exclusive segmental lever design provides linear transmission from float to pen
- Highest-Powered Pen Drive — large float with long travel
- Minimum Ambient Temperature Effects — float located in high pressure chamber

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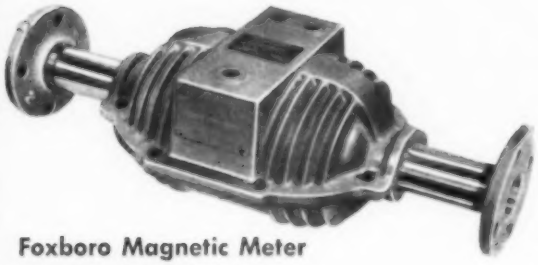

Foxboro Magnetic Meter

- Measures Fluid Velocity Directly
- Adds No Pressure Drop
- Uniform Flow Scale
- Overall Accuracy Better than 1% of Range Over Entire Scale
- Full Accuracy Sustained Even on Liquids Other Meters Can't Handle — even sand and water slurries

THERE ARE two logical reasons why Foxboro Instrumentation assures you *optimum* results in measurement or control of process fluid streams. First; Foxboro offers the widest variety of measuring and controlling devices . . . the *right* equipment for every application. For example, only Foxboro offers all these basic meter types: differential pressure cell flow transmitters, magnetic meters, mercury meters, and weir meters. Second; Foxboro provides 45 years of engineering experience in every phase of fluid mechanics. From the simplest general utility-type instrument to complex automatic ratio control systems, you get highest accuracy, efficiency, and economy. Whenever you have a flow problem involving liquids, vapors, gases, or slurries — in pipes, ducts, or channels, you can solve it best by specifying Foxboro. Only a few instruments are described on these pages. For full details; or for specific information on *your* problem, contact your nearby Foxboro Field Engineer, or write **The Foxboro Company, 384 Norfolk Street, Foxboro, Mass.**

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Float-and-Cable Type Meters

- Rigid Construction — weather-tight case; all working parts of corrosion-resistant materials
- Powerful Accurate Operation — large, high-stability float; cable of Type 302 Stainless Steel — non-stretching, non-twisting
- Direct Reading Chart and Scale
- Direct Reading Integral Counter

Other Foxboro Flow Instrumentation

Electric or Pneumatic Type Rotameters

Electric, Pneumatic, and Mechanical Integrators

Planimeters

All Primary Elements, Valves, and Accessories required for assembly of complete flow measurement and control systems

SEALTIGHT PIPE SHIELD

. . . The practical answer to PERMANENT PROTECTION against all ROCK DAMAGE!

Effective "holiday-free" pipe protection

Sealtight Pipe Shield provides an easily workable protective shield for pipes in every type of terrain or installation. It is the one completely effective and economical answer to "holiday-free" pipe shielding . . . eliminates the expense of dirt padding. Penetration tests show that even large rocks fail to rupture this material. Ideal for protecting pipe sections pulled across swamps . . . replaces ineffective, costly wooden slats or snow fence materials in shielding coated pipes at river crossings and under river clamps. Sealtight Pipe Shield is impervious to stress and strain of soil movements—unaffected by soil chemicals and moisture. Records of on the job tests prove Sealtight Pipe Shield far more effective and less costly than ditch padding installations.

EASILY APPLIED

Sealtight Pipe Shield is quickly and easily installed by untrained crews. The necessary straps, tools and seals are available and can be shipped as a complete package when desired.

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WITH THE PIPELINE CONTRACTORS

● **Collins Construction Company, P. O. Box 86, Port Lavaca, Texas.** Has contract for laying 37,000 ft of 22-in. concrete coated line for the *City of Los Angeles*, California. Line will serve as ocean outfall for sludge from Hyperion Treatment Plant at El Segundo, and will extend from El Segundo beach to a depth of 300 ft in the Pacific Ocean.

● **Houston Contracting Company, 2707 Ferndale Place, Houston 6, Texas.** Has 121 miles of 30-in. natural gas line for *Texas Eastern Transmission Corporation* from a point near Angleton, Texas, east to a point near Vidor, Texas. Work is being handled by three spreads; pipe laying began between March 2 and March 15.

● **H. B. Zachry Company, Box 2570, San Antonio 6, Texas.** Has 330,000 ft of 4½-in. line for *Phillips Petroleum Company* between Coke County and Midland County, Texas. Has three spreads of 30-in. line and river crossings for *Texas Eastern Transmission Corporation*. One spread of 353,700 ft extends from the Rio Grande River to the King Ranch; another, 358,500 ft between Port Lavaca and Highway 35. The river crossings are on the Rio Grande between McAllen and Vidor, Texas.

● **Panama-Williams Corporation, 1418 Melrose Building, Houston, Texas.** Has 76 miles of 4 and 6-in. line for *Phillips Chemical Company* between Pasadena and Sweeny, Texas. Also has 46 miles of 10-in. LPG and natural gasoline line to lay for *Gulf Refining Company* between the company's Waddell plant in Crane County, Texas, to Midland. Contracts for the remainder of this 530-mile line, extending to Houston, are yet to be let.

● **Majestic Contractors Limited, 408 Royal Trust Building, Edmonton, Alberta.** Has gathering system to lay for *Westspur Pipeline* in the Midale, Saskatchewan, area. Has undetermined amount of city distribution system for *Consumer Gas Company* in Toronto. Has 85 miles of 30-in. line—Section 7—of *Trans-Canada Pipe Line, Ltd.*, natural gas line. This spread, with pipe laying to begin probably in June, is east of Winnipeg through territory largely muskeg and solid igneous rock.

● **River Construction Corporation, Box 9217, Fort Worth, Texas.** Has 84 miles of 8 and 10-in. line from Richmond to Stockton, California, to lay this spring for Southern Pacific Pipe Lines, Inc.

● **Canadian River Construction, 580 Hornby Street, Vancouver, British Columbia.** Has 150 miles of gathering lines in northern Alberta and British Columbia for *Westcoast Transmission Company, Ltd.*

● **Ted Price Construction Company, Electra, Texas.** Has 205 miles of 1 to 8-in. distribution system in Walla Walla, Washington, and Pendleton and Baker, Oregon for *Cascade Gas Company*.

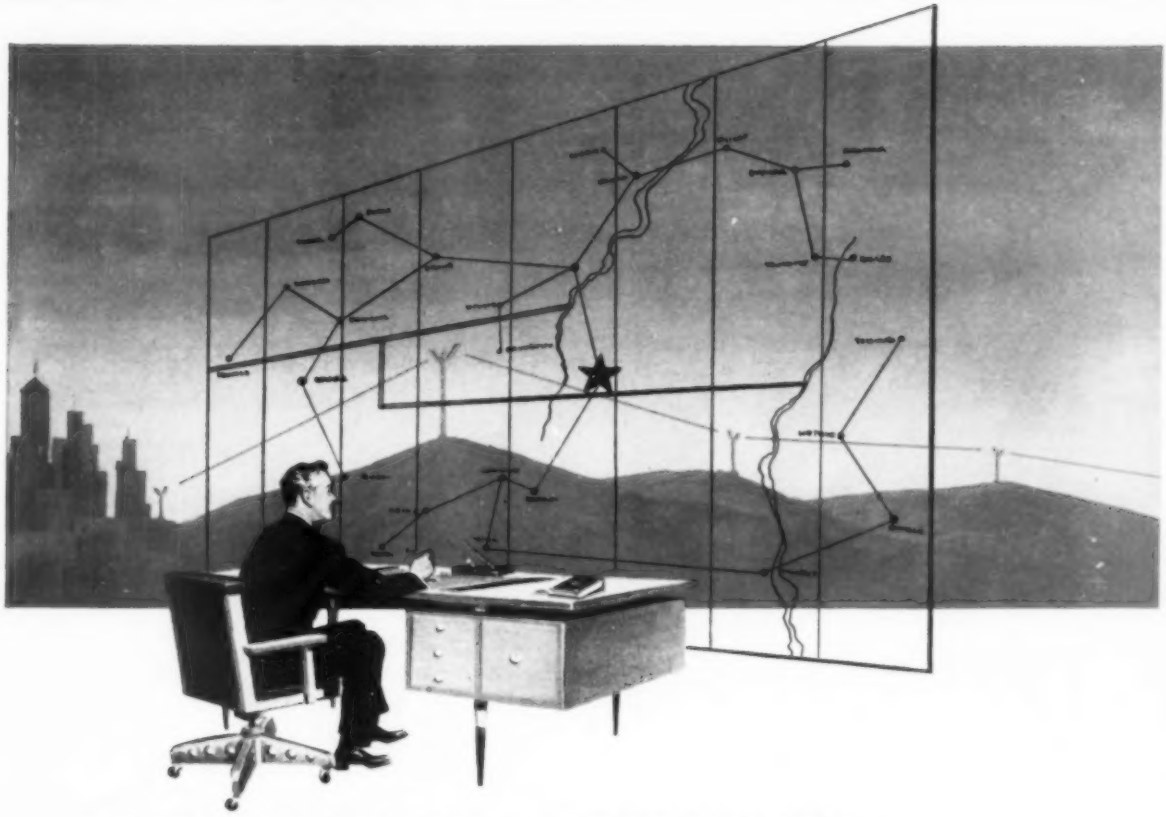
● **Troth Construction Company, Box 592, Britton, Oklahoma.** Has contract for 160 miles of 2 and 8-in. lines for gas distribution to communities in the Aberdeen, South Dakota, area, for *Northern Natural Gas Company*.

● **A. J. Curtis & Company P. O. Box 1072, Casper, Wyoming.** Has various town work laying 6 and 8-in. line in Kelso and Longview, Washington. *B & M Construction Corporation* is prime contractor.

● **Engineers Limited Pipeline Company, 200 Bush Street, San Francisco, California.** Has line for *Pacific Gas & Electric Company* consisting of 37 miles of 20-in., 37 miles of 18-in., and 9 miles of 12-in. to lay from Beehive Bend field to Sacramento, California.

● **Fulton Banister, Ltd., 625 Northern Hardware Building, Edmonton, Alberta.** Has 33 miles of 24-in. for *Interprovincial Pipe Line Company* between Peebles and Glenavon, Saskatchewan, to begin construction about June 1. Also has about 130 miles of 1 to 20-in. distribution lines in Regina City, Saskatchewan, for *Saskatchewan Power Corporation*.

● **Mannix, Ltd., 322 Seventh Avenue W., Calgary, Alberta.** Has 100 miles of 3 to 12-in. gathering line in the Pembina field to lay for *Pembina Pipeline Company, Ltd.* Has 110 miles of 30 in. for *Westcoast Transmission Company, Ltd.*, between Huntington and Kingsvalle, British Columbia. Has 90 miles of 34-in. to lay for *Trans-Canada Pipe Line Company* between Moose Jaw and Candiac, Saskatchewan. Has contract to lay 32 miles of 16-in. loop for *Pembina Pipe Line Company, Ltd.*, between Edmonton and Calmar, Alberta. Work on this project is to begin May 1.



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Motorola Microwave puts complete operational control at your fingertips

Cross-country or cross-town—Motorola Microwave can give you centralized control in one *complete*, privately-owned communication system that spans city streets, rivers, and mountains with ease. Multiply your present communication facilities with this work-horse that provides multi-channel facilities for transmitting and receiving orders and instructions by voice, printed messages and control signals. It will speed a thousand tasks a day, working 'round the clock to give you better control, improved coordination and increased efficiency . . . all at a substantial savings in cost.

With Motorola Microwave serving all types of applications (many of them in your industry) you get the benefit of extensive experience. In installation after installation, operational records prove that Motorola Microwave performs better, lasts longer and costs less to maintain.

Learn how Motorola Microwave can give you the *complete* communication system for centralized control. Write, wire, or phone today.

VOICE

Private line and party line—manual and dial telephone circuits—VHF mobile and base station 2-way radio . . . *all* can be carried hundreds of miles, economically and privately, by Motorola Microwave.

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Read a message, a chart or facsimile a thousand miles away in seconds. Assemble necessary information the fast, efficient way. Teleprinting, telemetering, telegraph, facsimile are at your command with Microwave.

CONTROL SIGNALS

Read meters, turn valves, from *any* central location you want. With Motorola Microwave you can have supervisory control, remote control, and remote indication. Greater efficiency at less cost.

MOTOROLA MICROWAVE

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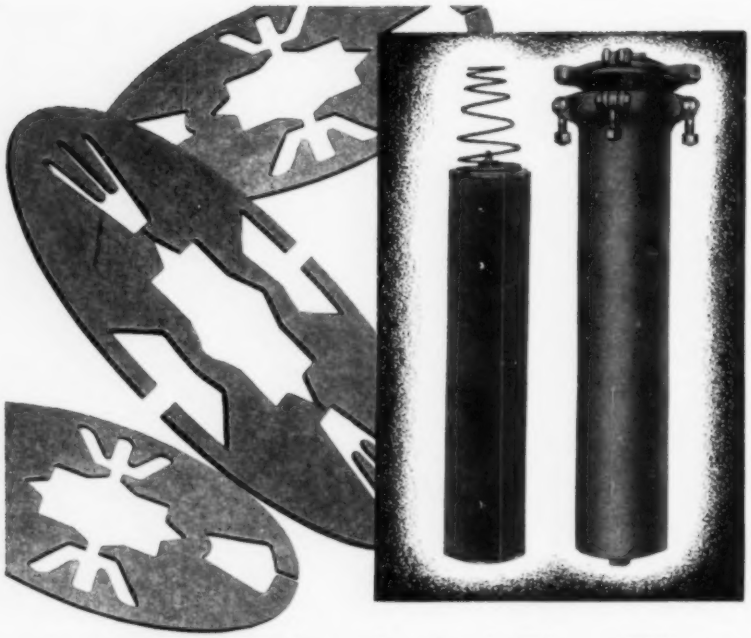

the NUGENT Laminated Disc Filter

This "extended area" filter utilizes an actual filtering surface area greatly in excess of its container area. The Nugent Laminated Disc Filter provides a high flow rate at low pressure drop combined with the extreme fine filtering absorption and neutralizing properties of a depth type filter.

The filter charge consists of a stack of similar crenulated fiber discs, each rotated 45° from the position of the adjacent disc, thus affording proper channeling and maximum filtering capacity. Liquid passes from the exterior to the interior of the filter stack.

The filter recharge has a useful life of from 4 to 10 times that of a cellulose or waste recharge. Changing recharges requires only minutes. Cartridges are interchangeable with all other Nugent bag or depth type cartridges. Write for full details.

DESIGN FEATURES

- Provides "Extended Area" filtering
- Removes solids as small as 2 microns
- Removes acid forming contaminants
- Will not remove additives
- Contains no chemicals or bleaches
- Working pressure 125 psi—tested to 375 psi
- High pressure filters to 600 psi—tested to 3000 psi
- Built in by-pass relief
- Maximum operating temperature 375° F.

HOW IT WORKS

Each disc in filter stack is rotated 45° from position of adjacent disc for proper channeling and maximum filtering capacity.

Established 1897

Wm. W. Nugent & Co., Inc.

3424 Cleveland Street Skokie, Illinois

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Contractors

● **Dunn Bros., Inc., 801 Mercantile Securities Building, P. O. Box 5771, Dallas, Texas.** Has 105 miles of 34-in. for *El Paso Natural Gas Company* between St. Michaels and Navajo Station, Arizona. Has 145 miles of 34-in. line for *Western Pipe Line Company* east of Flagstaff to Topock, Arizona.

● **O. R. Burden Construction Corporation, P. O. Box 5216, Tulsa, Oklahoma.** Has 8 miles of 20-in. to take up in the vicinity of Roland, Arkansas, for *Magnolia Pipeline Company*. Has completed laying a similar amount of new line paralleling take-up job.

● **Dutton-Williams Bros., Ltd., North Canadian Oils Building, Calgary, Alberta.** Has 320 miles of 10 through 4-in. distribution systems for *Inland Natural Gas Company* in Nelson, Savona, and Penticton, central British Columbia.

● **R. H. Fulton & Company, Inc., P. O. Box 1526, Lubbock, Texas.** Has 25± miles of 22-in. line for *Colorado Interstate Gas Company* between Rock Springs and Laramie, Wyoming. Has 78.4 miles of 26-in. line in the Minnesota section of *Interprovincial Pipe Line Company's* main line loop.

● **Latex Construction Company of Georgia, P. O. Box 184, Fond du Lac, Wisconsin.** Has 90 miles of 16 and 20-in. line between Oshkosh and Milwaukee, Wisconsin, for *Michigan-Wisconsin Pipe Line Company*.

● **Somerville Construction Company, Ada, Michigan.** Has 67 miles of 10 and 12-in. line from Clare County to Traverse City, Michigan, for *Michigan Consolidated Gas Company*. Also has 60 miles of 10 and 12-in. line between Muskegon and Ludington, Michigan, for the same company.

● **Williams Brothers Company, National Bank of Tulsa Bldg., Tulsa, Oklahoma.** Has 212.5 mile 20-in. crude line for *Socony Mobil Oil Company de Venezuela*. Line will extend from San Silvestre field to Puerto Cabello on the Caribbean Coast.

● **H. C. Price Company, Box 1111, Bartlesville, Oklahoma.** Has 71 miles of 30-in. line for *Texas Eastern Transmission Corporation* in the Port Lavaca, Texas, area.

● **Trojan Construction Company, Inc., 1416 N. Robinson, Oklahoma City 3, Oklahoma.** Has contract for takeup and reconditioning 276 miles of 8-in. line for *Sinclair Pipe Line Company* between Jacksboro and Mexia, Texas.

● **Eastern Pipeline Contractors, Mercantile Bank Bldg., Dallas, Texas.** Has contract for 89 miles of 6 and 8-in. line for *Gulf Refining Company*, from a point westward from Midland into New Mexico, near Hobbs.

● **Price-Poole Pipeline Constructors of Canada (joint venture of H. C. Price of Canada Limited and Poole Construction Company, Ltd., Rivers, Manitoba.** Has 99-mile section of 34-in. pipe to lay for *Trans-Canada Pipe Line Company* on a section of line in Manitoba Province extending eastward from the Assiniboine River near Miniota. Right of way has been cleared and limited activity is underway prior to actual construction beginning this spring as weather permits.

ON-THE-SPOT

SERVICE

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- **All Gaso distributors are carefully chosen for their responsibility and service-mindedness.**
- **All Gaso distributors are equipped by training and experience to make sound recommendations of models and sizes.**
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So far as service is concerned, we are as close to you as our nearest distributor. It's an important advantage . . . another reason why GASO has become known not only as the tradename of the industry's best known portable pumps but as a *symbol of pumping service* that extends through all phases of selection, delivery and performance.

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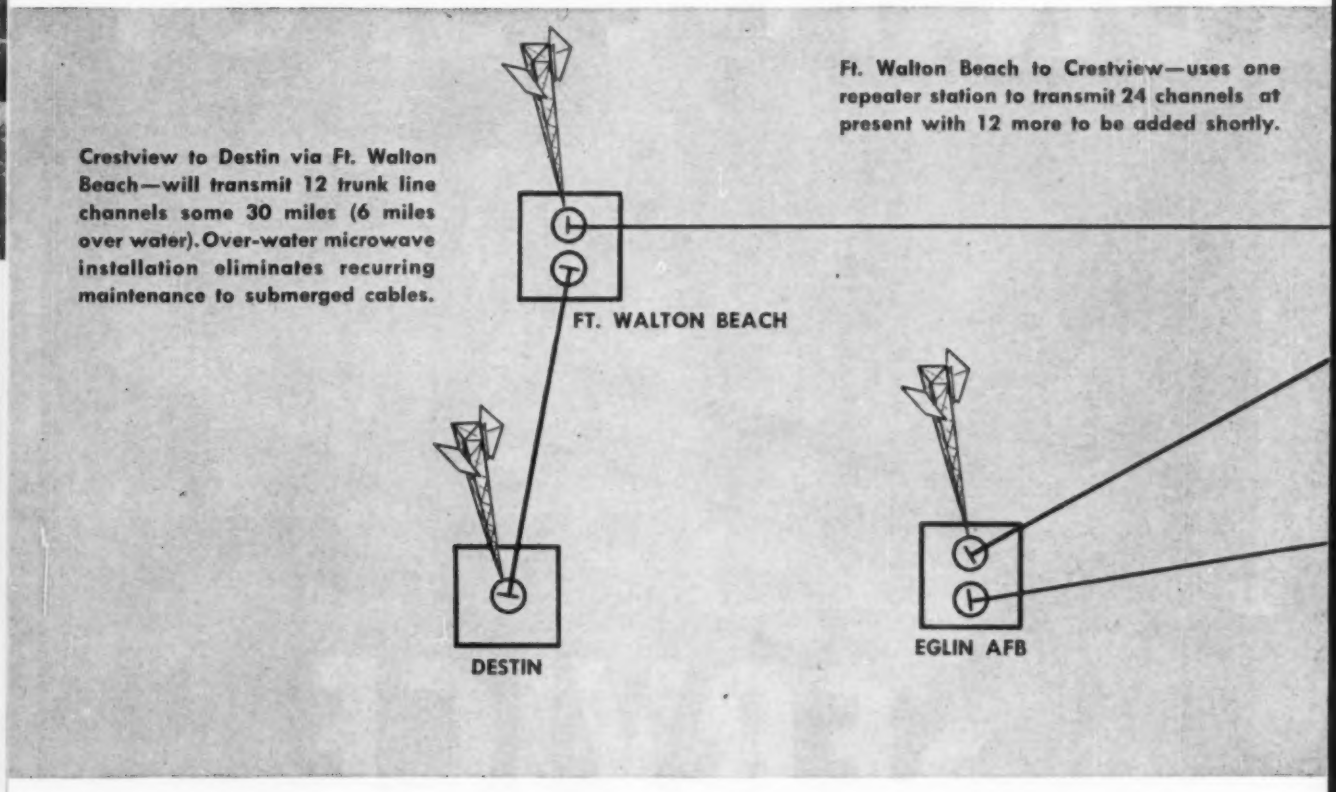
Crestview to Destin via Ft. Walton Beach—will transmit 12 trunk line channels some 30 miles (6 miles over water). Over-water microwave installation eliminates recurring maintenance to submerged cables.
Ft. Walton Beach to Crestview—uses one repeater station to transmit 24 channels at present with 12 more to be added shortly.
FT. WALTON BEACH
DESTIN
EGLIN AFB

Progressive Southeastern Telephone Company Repeatedly Specifies Philco Microwave In Dynamic Expansion Program

On the basis of proven reliability, economy and efficiency, Southeastern Telephone Co. selected Philco Microwave Equipment . . . has it in operation . . . and is installing more.

Multiple voice channeling, plus completely automatic dial system switching eliminate the need for manual switchboards at Destin and Ft. Walton Beach. Fallen transmission lines and service interruptions due to turbulent weather are a thing of the past. The need for submerged cable in the 6-mile over-water hop from Destin to Ft. Walton Beach has been eliminated entirely.

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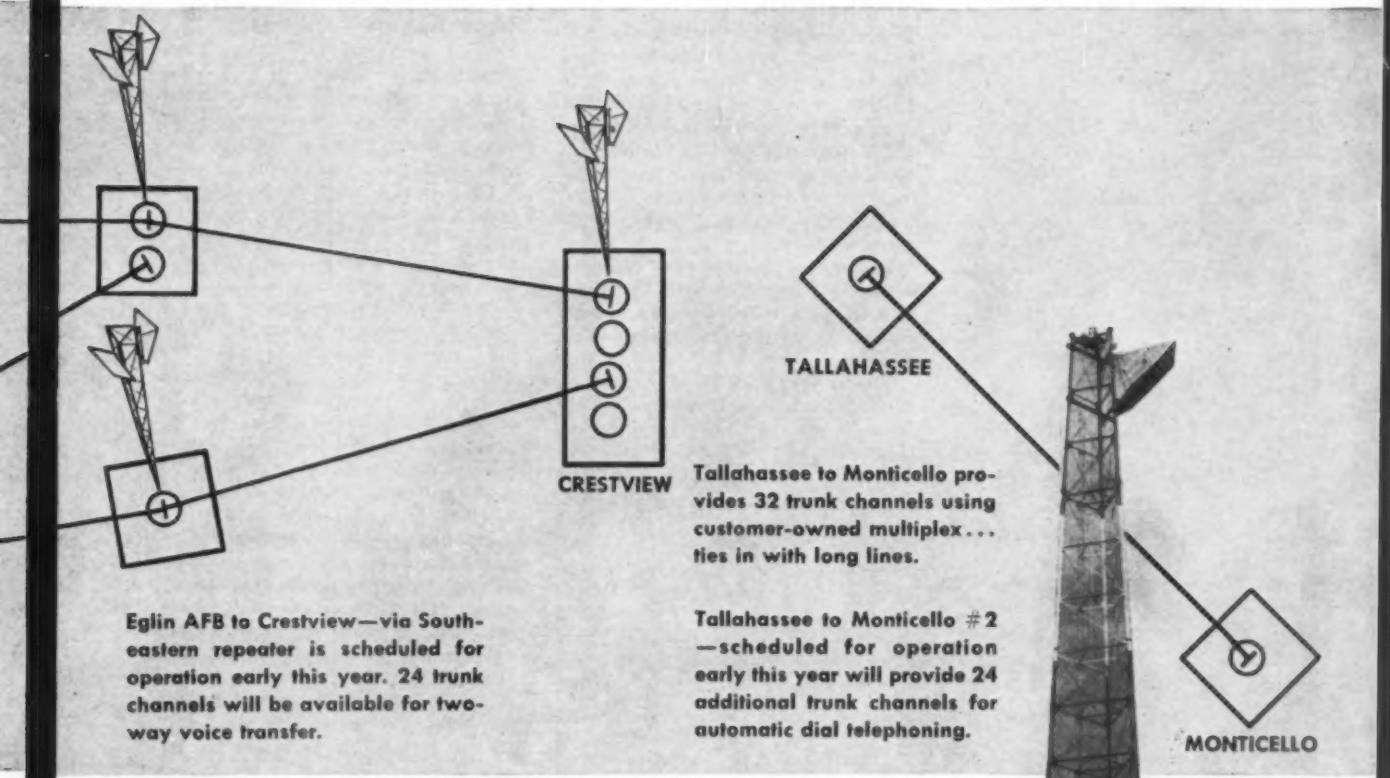


Tallahassee to Monticello provides 32 trunk channels using customer-owned multiplex . . . ties in with long lines.

Eglin AFB to Crestview—via Southeastern repeater is scheduled for operation early this year. 24 trunk channels will be available for two-way voice transfer.

Tallahassee to Monticello #2 —scheduled for operation early this year will provide 24 additional trunk channels for automatic dial telephoning.

Linking its central toll center at Crestview to *Ft. Walton Beach, Eglin AFB* and *Destin* with low cost, automatic dial telephone service, Southeastern Tel. operates a network of Philco multiple-channel microwave trunk line carriers. Multiple trunkline switching at Destin and Ft. Walton Beach centrals is completely automatic.

Pipe Line Projects

Transco Has $113,000,000 Program Planned

Transcontinental Gas Pipe Line Corporation has filed application with the Federal Power Commission for a certificate to construct $61,500,000 of new facilities as a major part of its total $113,000,000 construction program planned for this year.

Tom P. Walker, Transco president, said that a large part of the construction in this new application will be seven new main line intermediate compressor stations in Louisiana, Mississippi, Alabama, Georgia, North Carolina, and two in Virginia. Additional compressor engines will be installed in nine existing stations.

In Texas a total of 229 miles of gathering laterals will be laid to bring new gas reserves into the Transco system. These reserves are in Texas Railroad District 1. Five new gathering meter stations and five dehydration stations are planned.

This new application includes 42 additional miles of 36-in. and 16 miles of 30-in. loop lines, but Walker pointed out that most of the main line looping program for 1957 is contained in an application already before the FPC.

A few days after the application was filed, FPC gave final approval of a $50,900,000 construction program started last fall. Of the 350 miles of large diameter pipe in that application, 161 miles were laid last fall and early winter under temporary certificate. Also, 12,000 total additional hp was installed at compressor stations near Eunice, Louisiana, Tylertown, Mississippi, and Clanton, Alabama.

Remaining phase of that construction, 30-in. and 36-in. main line loops in nine states, will begin soon as final certification by the FPC has now been received.

Walker said work also has begun or will get underway soon on three lesser construction programs. One of these will be 28 miles of 16-in. lateral in Cameron Parish, Louisiana, to take Transco's first offshore gas purchase.

Total expansion of Transco facilities this year will cost in excess of $113,000,000. By the end of the year, Walker said, the daily allocations on the company's system will reach 945,000,000 cu ft, exclusive of the 136,000,000 already available from storage on cold days to distribution companies in the New York-New Jersey-Philadelphia area.

Way Cleared for Texas To Florida Gas Line

Two Florida utilities, Florida Power and Light Company and Florida Power Corporation, have accepted rate conditions imposed by the Federal Power Commission and thus cleared the way for construction of a gas line from South Texas into that state.

Late in February, FPC accepted rate filings by Coastal Transmission Corporation and Houston Texas Oil and Gas Corporation to meet conditions of its December opinion. Final authorization, however, hinged on fulfillment of certain remaining conditions.

These conditions required Houston Texas Oil and Gas to clarify its transportation agreements so that the power companies would not have the right to cancel on the ground that Houston Gas was performing transportation service at a lower rate for a third party, or because the transportation rates were lawfully changed. The commission also specified that Houston Gas eliminate sections of the rate schedules that contained automatic rate changes or references to other contracts.

Coastal's system will extend from southern Texas to the east bank of the Mississippi River where it will connect with Houston Gas' proposed facilities. The Houston Gas system will then extend across the Gulf Coast states and down the Florida peninsula to a point near Miami.

Coastal will supply all requirements of Houston Gas, which will be its only customer. Deliveries initially will average 248,642,000 cu ft per day, with a maximum of 273,506,000 cu ft daily. Approximately 150,000,000 cu ft of this gas will go to the two power companies.

Odessa to El Paso Products Line Announced

El Paso Natural Gas Products Company, El Paso, Texas, will lay 6-in. products pipeline from a point near Odessa, Texas, to El Paso, approximately 250 miles. The line will originate at a 6500-bbl refinery the company plans to construct. The company is a subsidiary of El Paso Natural Gas Company.

Ohio Fuel Gas to Add New Storage Facilities

The Federal Power Commission has authorized The Ohio Fuel Gas Company, of Columbus, Ohio, to construct and operate additional natural gas storage facilities and to abandon certain other facilities in Ohio.

Ohio Fuel's major proposal is the activation and development of a new storage field in Vinton County, to be known as the McArthur storage field, including the installation of 15.1 miles of various diameter pipeline and a 3300-hp compressor station. Initial input capacity of 10,000,000 cu ft a day will be increased to 85,000,000 cu ft daily in 1958. Output capacity will be 40,000,000 and 70,000,000 cu ft for the peak days of 1959 and 1960, respectively. Cost of this storage is estimated at $2,070,000, less net salvage of $19,200.

Ohio Fuel also was authorized to install superchargers and new compressors on units at the Wellington storage compressor station in Medina County, increasing the station's rating from 3200 hp and the daily input rate from 40,000,000 cu ft to 54,000,000. Output rate is 190,000,000 cu ft per day for the maximum volume to be stored.

Ohio Fuel will activate and develop two additional storage pools in the Holmes storage field in Holmes, Wayne, and Ashland counties, including the installation of approximately 16.4 miles of various diameter pipeline. Maximum daily deliverability of the pools will be 35,000,000 cu ft. Estimated cost of the facilities is about $362,000, less net salvage of $36,920.

The FPC granted the company authority to abandon existing compressors and piping at the Wellington station and 33.1 miles of line to be replaced by pipeline authorized for the Holmes and McArthur projects.

Arkansas Louisiana Plans A $30 Million Line

Arkansas Louisiana Gas Company has in the planning stage a $30,000,000 transmission line and a $5,000,000 gas exploration program. The two projects have been approved by the company's board of directors.

Preliminary studies will be made for construction of a gas line to connect Arkansas Louisiana's system to potential reserves on the Louisiana-Texas Gulf Coast.

The system will consist of approximately 300 miles of main line, gathering lines, and compressor stations.

Three Lines Talked From Hugoton Area

As a result of important discoveries of oil in the Hugoton field, Kansas, and the Anadarko Basin of southeastern Colorado, three pipelines are in prospect to move production from the area.

Shamrock Oil and Gas Company is studying plans for a line that would connect with the Arapahoe Pipe Line Company system, the ultimate destination of the crude being Chicago.

Dan W. Cameron, independent operator, plans a 105-mile, 8-in. line from the Sublette area to tie-in with the Arapahoe system. Ultimate capacity would be 50,000 bbl a day.

Charles Coates, independent producer of Wichita, Kansas, is reported having conferred with financial interests about a 16 or 20-in. pipeline to be laid from Haskell to Humboldt, Kansas.

The Haskell area is said to have reserves of 100,000,000 bbl, based on geological studies.

El Paso Proposes $107,100,000 Facilities

El Paso Natural Gas Company has asked authorization from the Federal Power Commission for construction and operation of $107,100,000 in pipeline facilities.

Proposed main line facilities, in Arizona, Texas, and New Mexico, include 216 miles of 6⅝-in. to 34-in.; 58,900 hp in new and existing compressor stations, metering and appurtenant facilities.

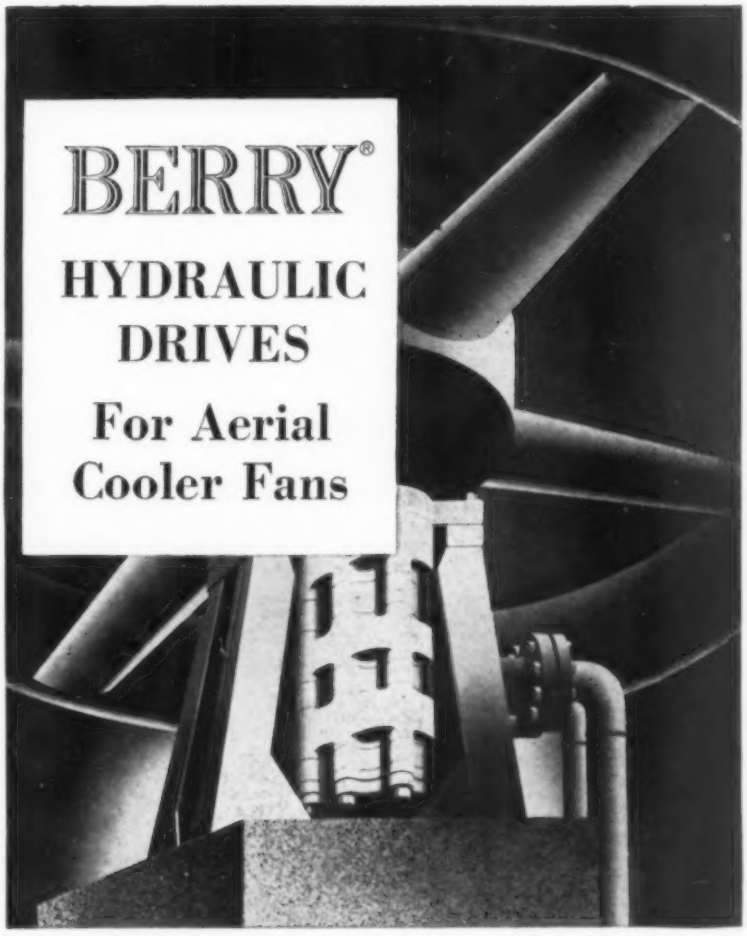
Field facilities proposed in the application include approximately 533 miles of varying diameter pipeline, 27,850 compressor hp, and appurtenant facilities.

El Paso proposes to sell to Southern California Gas Company and Southern Counties Gas Company, an additional 75,000,000 cu ft daily; to Pacific Gas & Electric Company, an additional 75,000,000 cu ft per day, and an additional 35,000,000 cu ft daily to existing customers in Arizona, principally in the Yuma, Arizona, area.

PG&E to Build Gas Line to Cement Plant

Arrangements are under way for a 14-mile natural gas pipeline from Santa Cruz to serve the Pacific Cement and Aggregates, Inc., cement plant at Davenport, California, Pacific Gas and Electric Company has announced.

The $780,000 project will provide a 12-in. line to the cement plant, with PG&E to supply it 8,000,000 cu ft of natural gas a day. Construction will begin when final rights-of-way are obtained. It is expected that work will be completed by August 1.



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constant water temperature • The Berry drive makes it possible to maintain a predetermined jacket-water temperature accurately and automatically.

safe • The Berry hydraulic system has the safety necessary for gas transmission equipment and can be located in compressor building at point of use.

simple, trouble-free • Fan may be mounted directly on Berry hydraulic motor shafts, and the pump may be direct or belt driven from compressor flywheel.

saves power • With the Berry hydraulic drive, horsepower used to drive fan is proportionate to the cube of the speed of the fan. Whereas with a mechanical drive, the horsepower remains constant.

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adaptable • With Berry's "stacking" design, *one* Berry hydraulic pump can provide power for a number of Berry motors under various oil flow and pressure requirements.

low overall investment • The integrated hydraulic drive, powered from compressor, eliminates hazardous electrical equipment and additional buildings necessary.

fully automatic • When untended service is a "must," Berry drives can be integrated with other controls to provide automatic compressor stations.

See how Berry fills your needs.

Write for this 8-page bulletin which gives full data on Berry pump/motor "package" units.

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FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Projects

Magnolia to Boost West Texas-Gulf Coast Capacity

Magnolia Pipe Line Company says it will increase its crude carrying capacity from West Texas to the Gulf Coast by 75,000 bbl per day, completing the project during the first quarter of 1958.

The increased capacity will be achieved by filling in loops and adding pumping equipment along the company's present main line that extends from Midland to Beaumont. The addition will boost Magnolia's total crude capacity out of Midland to 235,000 bbl per day.

L. H. True, president of the pipeline company, said consideration of an expansion program began in September 1956, when Magnolia called a meeting of industry representatives to talk over the developing shortage of capacity.

As a result of the meeting, seven major carriers made an engineering investigation in October that showed a large-diameter line would be needed to meet the requirements of the participating carriers, True said. Steel mill schedules would not permit completion of the line until 1960, however.

The delay involved and the fact that other carriers no longer had available space prompted the company's decision to undertake expansion of its own system.

"We decided our own needs were too urgent to wait for the 'big-inch' pipe that the joint project would have required," True stated.

Investigation had shown that pipe in smaller sizes could be delivered in 1957. Magnolia obtained commitments for pipe and ordered materials and equipment in December 1956.

True said that the expansion move will help relieve the shortage of pipeline capacity out of West Texas, which "has been evident for months now and which had been in the forefront ever since the Middle East situation showed up last fall."

Compressor Station to Replace Old in East

Federal Power Commission has granted authorization to The Manufacturers Light and Heat Company to construct and operate a 5280-hp compressor station and other related facilities in Marshall County, West Virginia. The cost of the facilities is estimated at $3,588,000.

The new compressor station will replace the existing 2500-hp Majorsville compressor station in Washington County, Pennsylvania, approximately one-half mile from the site of the proposed station. Manufacturers proposes to abandon the existing station at the end of the 1957 storage input season.

Southern Natural to Tie-in New Gas Reserves

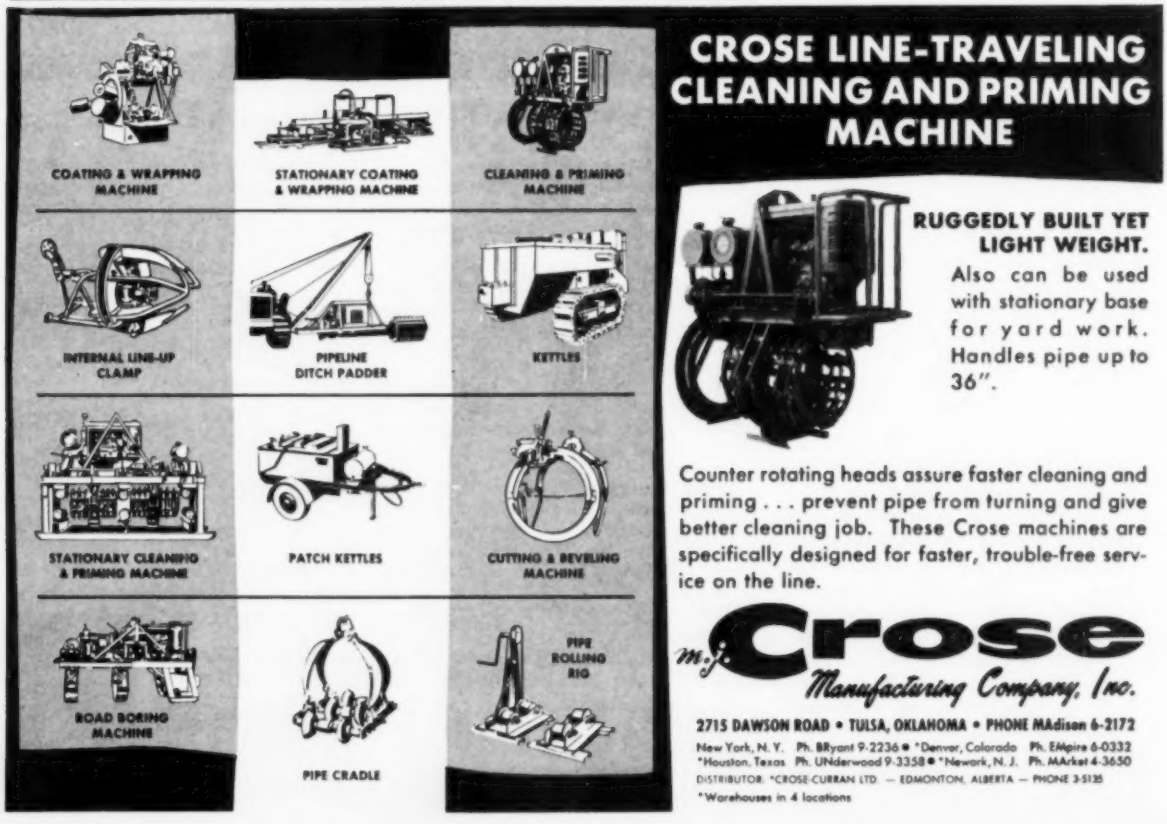
Southern Natural Gas Company will construct 10.5 miles of 8⅝-in. pipeline, including a submarine crossing of the Mississippi River; two measuring stations; install two 660-hp compressor units at the Toca station, one 550-hp compressor at the White Castle station, and one 1350-hp unit at the Gwinville station.

Additional gas reserves from the Napoleonville field, Assumption Parish, and Fort Jackson field, Plaquemines Parish, Louisiana, will be made available by the new facilities.

Short Loop Will Give Needed Pressure

Texas Illinois Natural Gas Pipeline Company has been authorized by FPC to construct approximately 9.55 miles of 36-in. transmission line, looping its existing single 30-in. line from a point on the north bank of the Illinois River to its Joliet regulator station, serving the Chicago area.

The loop will maintain adequate pressure on the company's system north of the Illinois River to enable it to deliver the quantities of gas required at the Joliet meter station delivery point and at delivery points on its Volo lateral.



CROSE LINE-TRAVELING CLEANING AND PRIMING MACHINE

RUGGEDLY BUILT YET LIGHT WEIGHT.

Also can be used with stationary base for yard work. Handles pipe up to 36".

Counter rotating heads assure faster cleaning and priming . . . prevent pipe from turning and give better cleaning job. These Crose machines are specifically designed for faster, trouble-free service on the line.

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HOW BELL SYSTEM COMMUNICATIONS SERVE THE PIPELINE INDUSTRY

Construction men fought terrain and bitter cold in the construction of PNW's "scenic-inch" pipeline.

Why communications have to be good on Pacific Northwest's "scenic-inch" line

Pumping gas over mountain passes across 1487 miles of America's toughest terrain requires the most reliable communications available.

Pacific Northwest Pipeline Corp. presented this requirement to the Bell System, with one additional request—economy.

The result is a private line telephone system that PNW's Salt Lake City control center uses to keep a running summary of conditions along the line. Information gathered in Salt Lake City from each compressor station includes dew point, BTU content and specific gravity of the gas. Dispatchers use this data as guidance in controlling flow.

. . .

Bell System communications can work for you as fast and reliably. Just call your Bell Telephone Company business office. A representative will gladly discuss your requirements.

Pacific Northwest's Salt Lake City dispatchers collect data hourly from every compressor station and maintenance point on the company's 1487-mile pipeline.

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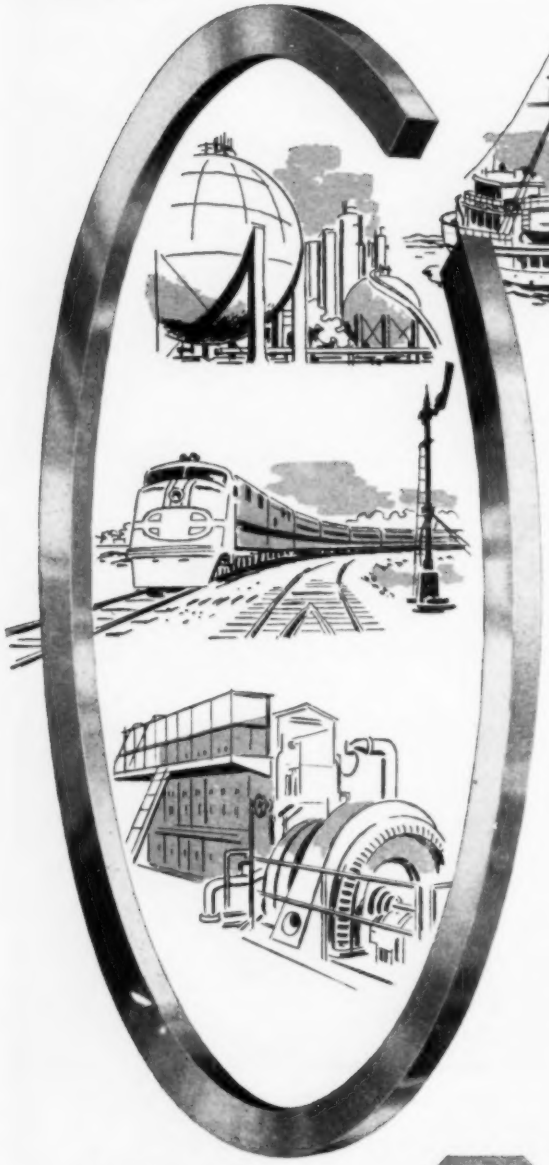

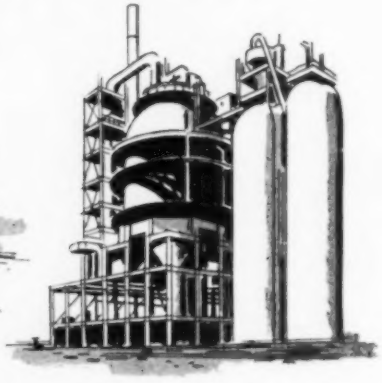

Why not specify piston rings that have *proved* themselves? Koppers rings have been saving money and cutting costs for years—throughout the oil and gas industry, the marine industry, on major railroads, all over the chemical field, throughout the aircraft business, in municipal and industrial power plants everywhere—wherever you find gas, Diesel or steam engines, pumps, compressors, forging hammers—*wherever piston rings are needed!*

They're built to take it . . . designed to cut downtime and maintain high compression . . . give longer, more satisfactory service . . . save you money on fuel and lubricating oil . . . *and that's exactly what they do.* And Koppers rings are available in all types, all sizes—from ½″ to 10′ diameter—specifically designed for the job they will do in the field where they will be used.

Always specify American Hammered Piston Rings. Benefit from over 100 years of experience in metal products. Use Koppers' complete engineering and metallurgical staff. Get skilled analysis of your specific problem, and prompt assistance. For 16 page Piston Ring booklet write to: KOPPERS COMPANY, INC., *Piston Ring & Seal Dept.,* 1704 Hamburg Street, Baltimore 3, Maryland.

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NEW Pipeline Equipment

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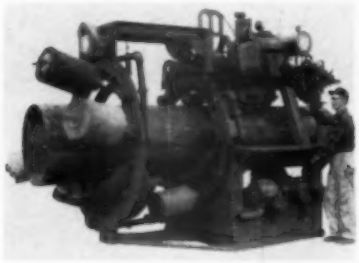
For more information on items described here in brief, use the handy reply card and circle the corresponding numbers

Line Traveling Machine. M. J. Crose Manufacturing Company, Inc., introduces a new line traveling machine for double coating and double wrapping pipe up to 40 in. in diameter. The first one of its capacity ever constructed for the pipeline

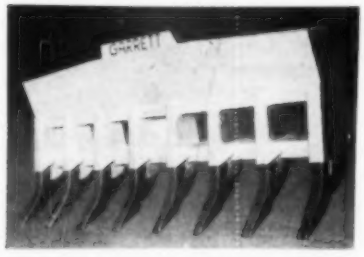


industry will go into immediate service on pipeline construction projects in the Kuwait area.

It will double coat and wrap pipe ranging from 30 to 40 in. diameters. Very compact and relatively light in weight, it has a variable speed reducer to eliminate chains and sprockets. *M. J. Crose Manufacturing Company, Inc.*

Circle number (81) on reply card.

Land Clearing Blade Features. Skeleton-like design of the Garrett Land Clearing Blade for Caterpillar D-8 tractors aims at strength without excess weight. The teeth, of high tensile forged steel, extend 6 in. beyond the moldboard and form a rolling



curve, so that large chunks are kept in motion and loose material can fall clear. Skeletonizing helps to prevent clogging and gives operator improved visibility *Garrett Distributors.*

Circle number (82) on reply card.

Torque Converter Drives. Twin Disc Clutch Company has developed a new 1300 series single-stage unit for high-speed diesel and gasoline engines. Applications lending themselves to the new torque converter are shovels, front-end loaders, industrial hoisting machinery, and a multitude of others where single-stage torque converters may have advantageous characteristics. Converters are for engines producing from 30 hp at 1450 rpm to 212 hp at 3200 rpm. Specific torque ratings are 165, 200, 240, 285 and 330 lb-ft, depending on the impeller blading selected. Maximum input torque is 350 lb-ft. *Twin Disc Clutch Company.*

Circle number (83) on reply card.

Large Capactiy Cooler. Niagara Blower Company has designed the Aero After Cooler of large capacity. It offers a self-contained method of cooling and removing the moisture from compressed air, independent of a large supply of cooling water and replacing both shell and tube cooler and cooling tower. It also combines in one machine provision for cooling compressed air and also for cooling water in a closed system for intercooler and compressor jackets.

Apparatus consists of two parallel mounted cooling coils (one for jacket water and one for compressed air) in separate casings joined to a central plenum. Sprays of recirculated water constantly drench these coils. Evaporation transfers the heat of compression, at the rate of about 1000 Btu per lb of water evaporated, to the air stream. Air enters above the coils, travels down through them and moves into the central plenum dropping its entrained moisture. *Niagara Blower Company.*

Circle number (84) on reply card.

Safety Switch and Pressure Gage. High and low pressure contacts on the one instrument is used to shut down equipment or sound an alarm, flash lights or operate other types of controls on pipeline pumps, water flood projects, gas compressor stations or where either high or low pressures could cause damage to unattended equipment. *Frank W. Murphy, Manufacturing, Inc.*

Circle number (85) on reply card.

Transient Converter. Fischer & Porter announces development of a transient converter for use with turbine-type flowmeters. Converter accepts a sinusoidal-type input signal of varying frequency and provides either an analog output for recorders and oscillographs or a digital output to counters and computers. *Fischer & Porter Company.*

Circle number (86) on reply card.

Coupling for Grooved End Pipe. A new flexible coupling for grooved end pipe is now marketed by Charles E. Manning. In sizes 1 in. to 8 in., the Alumiron Coupling is available in either malleable iron or aluminum and is furnished with Buna N or Neoprene gaskets. For use on steel, aluminum, cast iron, wrought iron and spiral weld pipe, the Alumiron can be

quickly coupled or uncoupled by means of two bolts which pass through the coupling halves. Use includes long, surface runs over rough, uneven country on service pipe to drilling rigs, Christmas tree, tank farms, stock and transfer lines. *Charles E. Manning Company.*

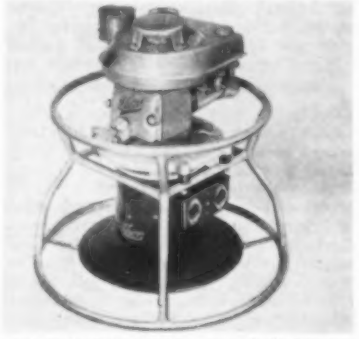
Circle number (87) on reply card.

Pipe Coupling Machine. Faster pipe installations are made possible by a pipe coupling machine designed and built by Davis Manufacturing Company. Eliminating chains and tedious assembly, the Davis Pipe Coupling Machine is made in various

sizes for installing all types of pressure-type joints 6 in. through 16 in. diameters. Another important feature of the new coupling machine is the simplicity of its operation. Easy-grip handle pushes to uncouple, pulls to couple. *Davis Manufacturing Company.*

Circle number (88) on reply card.

Vertical Shaft Feature of Generator. Thor Power Tool Company enters the portable electric generator field with two 1,500 watt models featuring a revolutionary vertical shaft design. With the vertical shaft, the entire weight of the generator is supported by tubular framework. Entire as-

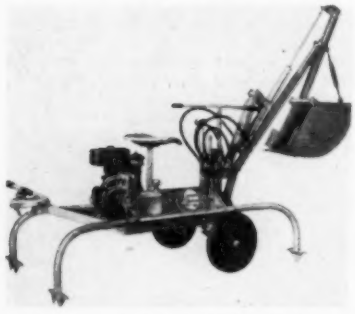


sembly floats in the framework that serves also as protective guard and carrying handle.

Powered by gasoline engines, the two new Thor models—EG-1.5A for a-c and EG-1.5D for d-c—provide 13 amperes of 115-v current for operation of electric drills, saws, hammers, concrete vibrators and other tools on construction sites. *Thor Power Tool Company.*

Circle number (89) on reply card.

Midget Backhoe. Portable, powered backhoe designed by The Charles Machine Works Inc. is capable of digging to a depth of 5 ft for trenches, bell holes and excavations. Ditch-Witch Backhoe is a trailer unit, weighs 500 lb and has its own gasoline power unit and hydraulic system. New tool will be used in digging sewer and



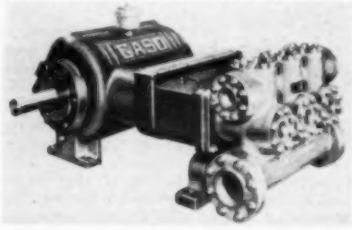
service lines, bell holes for maintenance and connections on pipelines and mains. *The Charles Machine Works Inc.*

Circle number (90) on reply card.

Pipe Easier To Lay. Pipeline laying and maintenance has been made easier with the development of Busada Butyrate plastic pipe for water, petroleum, natural gas, and other fluid transmission. Flexible plastic pipe weighs but a fraction of what an equal length of iron or other metallic pipe scales at, and in addition it can't rust. Pipe is transparent, which makes for quicker visual inspection. *Busada Manufacturing Corporation.*

Circle number (91) on reply card.

New Triplex Plunger Pump. Gaso Pump & Burner has added a new 2½ in. to 3½ in. by 4 in. horizontal triplex plunger pump, fig. 3466. Unit is a high-speed, single-acting pump for use where moderate capacities and medium to high pressures are required for crude oil gathering



systems, movement of refined petroleum products, salt water disposal, waterflooding and fresh water supply. Maximum speed is 250 rpm. Maximum capacities range from 91 bbl per hr at 1180 psi to 179 bbl per hr at 600 psi. *Gaso Pump & Burner Manufacturing Company.*

Circle number (92) on reply card.

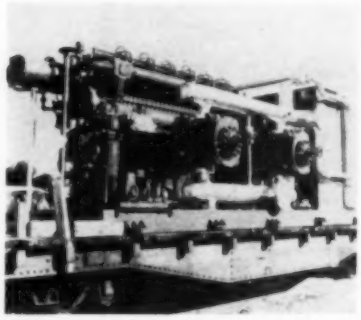
Cast Steel Solenoid Valves. A new line of cast steel solenoid valves for liquids to 600 psi is available in sizes 2 in. to 4 in. They are both globe or angle pattern with screwed or flanged pipe ends. Features include renewable seat rings, unbreakable piston rings and packless operation over a wide pressure range. *J. D. Gould Company.*

Circle number (93) on reply card.

General-Purpose Mild Steel Electrode. Manual arc welding electrode, with GE designation W613B, is heavily coated mild steel, designed to operate on either ac or dc, in all positions. The moderate arc force is sufficient to give adequate penetration, according to company engineers, and the steady spray-type transfer aids in control and direction of the deposit. *General Electric Company.*

Circle number (94) on reply card.

Turbocharged Engine Compressor for Gas Gathering. One of the first turbocharged gas engine compressors for use in field gas gathering is made available in the SLHC line introduced by Worthington. The 5 SLHC units are rated from 340 to

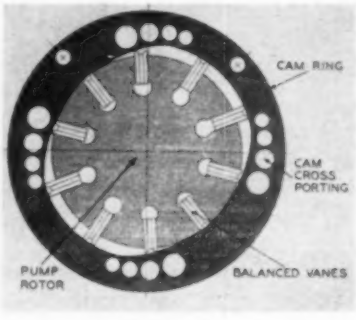


over 1000 hp at 450 rpm. Fitted with a complete line of compressor cylinders, applications are considered to be in the gas transmission, gas processing, field gas gathering and petrochemical installations. *The Worthington Corporation.*

Circle number (95) on reply card.

New 2000 Psi Vane Pump. Series of balanced vane hydraulic pumps for continuous 2000 psi service has been introduced by the Denison Engineering Division, American Brake Shoe Company. The "T" series pumps feature hydraulically balanced vanes and are offered with deliveries of up to 100 gal per min at speeds up to 1800 rpm.

Two bolt threaded flanges are provided as standard equipment but four bolt hydraulic connections are available for those



desiring to use SAE four bolt split flange connectors. A nose type shaft seal, designed to withstand inlet pressures up to 100 psi gage, provides a positive type seal with considerably longer life than the lip type seal. This pump may be face, foot, or flange mounted in any of four positions on its mounting bracket. *Dension Engineering Division, American Brake Shoe Company.*

Circle number (96) on reply card.

NEW LITERATURE

Adhesives and Coatings. Data sheet titled "Adhesives and Coatings from Vinyl Ether Polymers and Copolymers" is released by General Aniline & Film Corporation. It discusses the applications of a series of 4 related polymers in the compounding of new adhesive and coating formulations. The polymers are used to give improved properties with such varied materials as polyvinyl acetate, natural rubber, animal glues, dextrin, polystyrene and polyvinyl chloride. *Commercial Development Department, General Aniline & Film Corporation.*

Circle number (97) on reply card.

Welding Chart. A wall chart (EW-198) on how to get better arc welding is available. This chart lists and gives instructions on the use of electrodes including carbon and low alloy steel, iron powder, hardfacing and build up, cast iron, nonferrous, and stainless steel. The chart also reminds the welder of the 4 essentials of proper welding procedure, and shows types of joints, typical welding positions, standard steel shapes. *Hobart Brothers Co.*

Circle number (98) on reply card.

Rigid PVC Plastic Pipe. An 8-page folder on Kraloy, rigid PVC plastic pipe, has been released by Kraloy Plastic Pipe. Technical data include tables, diagrams, and flow rate charts for the use of this pipe. *Kraloy Plastic Pipe Company, Inc., subsidiary of the Seamless Rubber Company.*

Circle number (99) on reply card.

Booklet on Working Pressures. "Allowable Working Pressures" is the title of a new booklet issued by Tube Turns. It is based on ASME Boiler Construction Code and the American Standard Code for Pressure Piping, ASA B31.1-1955. All data is well indexed and presented to enable the engineer to determine working pressures of piping in oil and gas transmission as well as in plant and process piping. *Tube Turns Division, National Cylinder Gas Company.*

Circle number (100) on reply card.

"Corrosion Keys for Aluminum." A new and more convenient guide to engineers in determining the corrosion resistance of aluminum has been published by Reynolds Metals Company. Titled "Corrosion Keys for Aluminum," the brochure is intended primarily as an aid to engineers designing aluminum into process plants or equipment, although it will be of interest to those concerned with other applications of the metal. *Reynolds Metals Company.*

Circle number (101) on reply card.

Cable Insulation. A new 28-page booklet, "How To Insulate A Cable," explains the 4 most-used methods employed by manufacturers for applying insulation to electrical conductors. It describes the advantages and the disadvantages of each. Wire and cable users will find the information in this booklet (Bulletin 1106) helpful in choosing the right cable design for their needs. *The Okonite Company.*

Circle number (102) on reply card.

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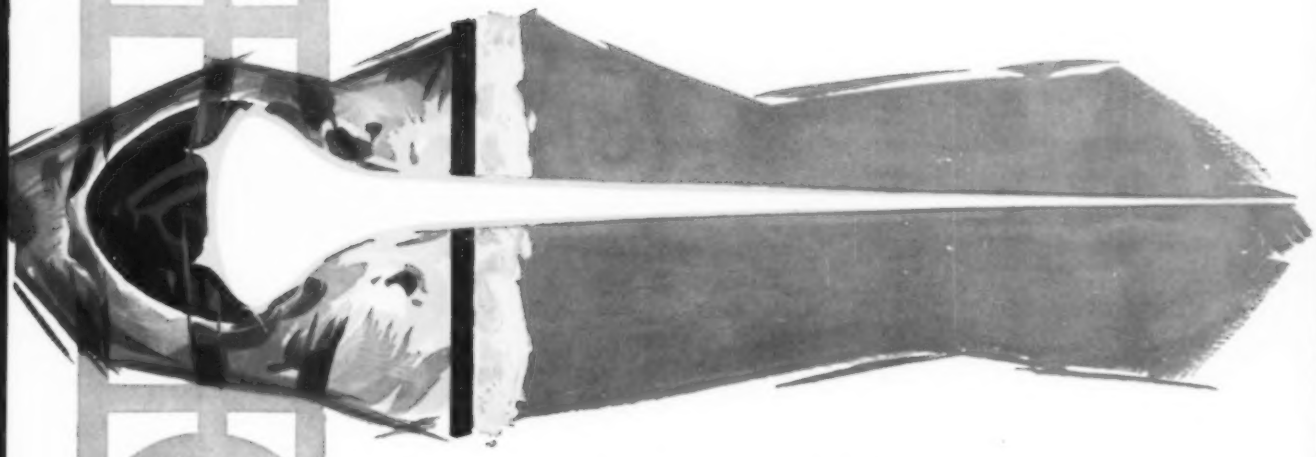

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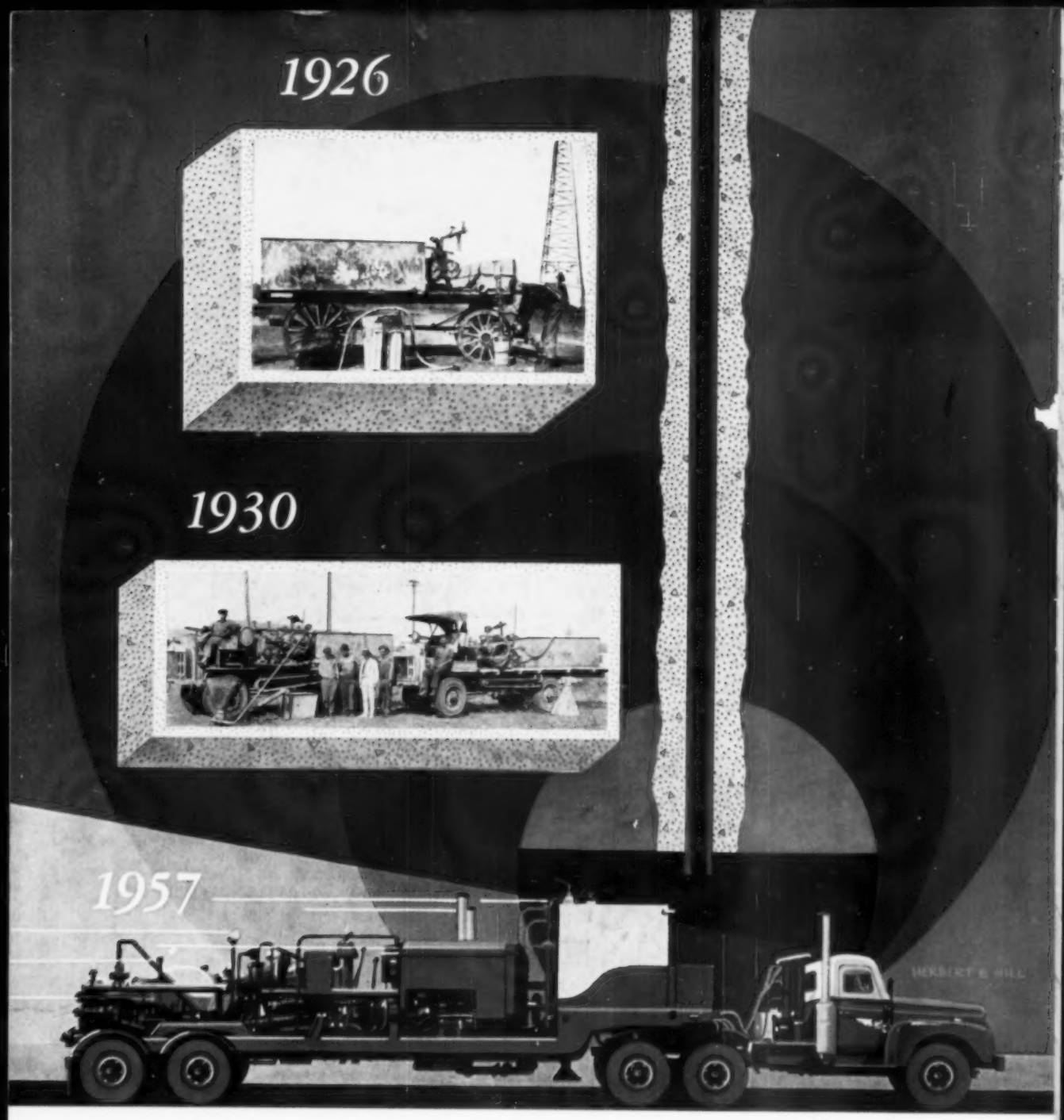

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